# Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, MAY, 1902. No. 3.

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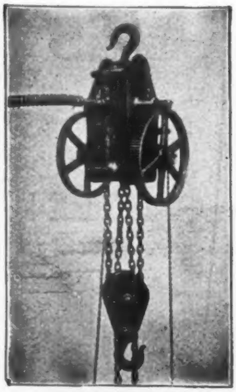

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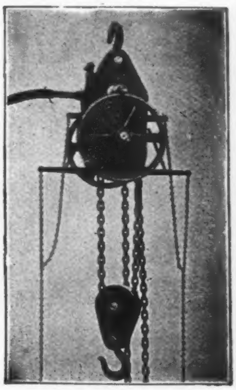

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# Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.



W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, - } Associates
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VOL. VII. MAY, 1902. NO. 3.


With this issue we publish in full a paper on "The Use of Compressed Air in Mining," by Mr. T. W. Barber, which appears in our contemporary, *The Iron and Coal Trade Review,* for April 4, 1902.

This paper will be of interest to our readers because in it are offered a number of reasons for the comparatively slow adoption of compressed air, even in cases where a parallel could be found as an example to study.

The first of his reasons, the fact that mining men as a rule are educated in the practical school of experience and are not given to depending much upon theory, was at one time true—and theory is often dangerous when practical work is concerned. Mining methods have not, as a rule, afforded an opportunity for much experimentation of the sort to develop new principles in compressor machinery. Generally such work is conducted in out-of-the-way places where experiments with the power plant are inadmissible. The inherent advantages of compressed air have, however, expanded the use of air beyond the bounds of mining and into factories and other work where opportunity for careful observation, changes and experimental modifications could be made.

As a consequence considerable improvements have been made through scientific logical study the same as has been largely responsible for the importance of electrical industry. Money has been forthcoming and inventive genius has led a growing chance to suggest and improve. The improvement in air compressing machinery resulting from this outside impulse has of necessity reacted toward the improvement of compressors used in mining. With the more extended use of compressed air has also come an improvement in the means for transmitting and the apparatus for using air. Other applications have come up and we now see the use of compressed air on the increase in a very gratifying degree

Certain defects or unfortunate features, formerly believed to be inseparable from compressed air, have been eliminated or so greatly reduced that air in mining has become as essential as hoisting machinery.

The question of cost of production, formerly the bugbear of those contemplating the use of air, and the main stock argument of its opponents is now well down the scale of importance and is surely sliding further down.

With guaranteed volumetric efficiencies in larger sized compressors of from 80 to 95%, and mechanical efficiencies of from 90 to 95%, most favorable comparisons can be made with electrical generators, which have been regarded as at the top notch of efficiency.

Transmission also, owing to great improvements in the methods of pipe manufacture, better methods for coupling and a better understanding of the laws governing the flow of air has resolved itself into a simple matter, permitting the prediction of results with certainty and with efficiencies which can be made anything desired from a fraction of a per cent. to the usual 5 to 10% adopted in electrical transmission. Comparisons of costs of installation no longer stagger those contemplating the use of air.

With cheap, satisfactory production and transmission of compressed air its future was insured. Mr. Barber's paper discusses all of these points in an interesting manner, which warrants attention.

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## Air For Power.

In the past few years there has been an enormous increase in the use of air for power purposes and new applications are being found for it every day which are surprising in their number and variety.

That so common a substance as *air* should be so readily adapted to accomplishing desirable mechanical results makes the subject of interest to the general observer, while to the trained worker the possibilities of its applications are enticing.

*Air,* of itself, *at rest,* possesses neither power nor energy which we can utilize. It is present in a practically inexhaustible supply, but is an absolutely inert substance, and as useless as any other form of matter unless acted upon from without. In common with other bodies it may serve as a transmitter of energy or power from a source of supply to a place where it may be used, or as a body in which energy may be stored and there kept until recovered at a future time.

When *air* is *in motion* it is capable of doing a certain amount of work. It possesses its energy by virtue of its velocity and is independent of both temperature and pressure. The first use of air for power was the application of the winds to move sailing vessels, windmills, and the like. Air set in motion by mechanical means and unconfined has but a relatively small use.

It is by working with *confined* portions of air that so great advances have been made within recent years. Under such conditions its value for work is concerned with the temperature, pressure and volume. These are inter-related according to certain well defined laws.

The *total* energy in a quantity of air in the gaseous condition is determined by its temperature alone. Changes in its pressure or volume do not at all affect its total energy providing the temperature remains unchanged. The *effective* or available energy, however, depends upon other conditions, and it is upon *these,* and the control we have over them, that the value of air as a power depends.

A given mass of air will occupy a certain space depending upon the pressure and the temperature. As either of these are changed the volume of the air concerned will change correspondingly. If the pressure be increased the volume will decrease, and in an exact ratio, if other influences are not regarded. This fact may be expressed in the formula, "the volume varies inversely with the pressure," or "the pressure multiplied by the volume equals a constant." By "pressure" is meant here not the pressure as read from the pressure gauge, in which *zero* is the atmospheric pressure but *absolute pressure* is referred to, i. e., no pressure at all, or, the gauge reading *plus* the pressure of the air (14.7 lbs. per square inch).

The effect of temperature upon volume of air is to increase the volume with use of temperature. Temperature and pressure may act together to change the volume of a certain amount of air, or they may act separately, the other being kept constant. Generally both are concerned where air is compressed, or a better statement would be that volume, pressure and temperature are interdependent. These relations need to be kept in view in any consideration of the value of air for power. Conversion formulas and factors may be readily obtained for these changes. As we expend work upon air either by heating or compressing it, we thereby endue it with energy which it may part with later in doing work. Theoretically, all that it had received would be given off again in effective energy, but in

practice there is loss in volume by leakage, in pressure by friction losses and in temperature by radiation of heat. The loss by leakage should be so slight as to be negligible if conduits are properly made and installed. The loss by friction in transmission may be considerable and should be minimized so far as possible by the use of large conduits. It is claimed by some that the heat of friction counteracts the loss of energy, but it is very doubtful if this is of real value inasmuch as this heat with that otherwise imparted to the gas, is liable to loss by radiation. Protective nonconducting coverings lessen heat losses very materially, and many ingenious devices are in use whereby the loss is in a measure counterbalanced.

Air, then, is an inert substance, inexpensive, inexhaustible in supply, upon which we may expend work, then store it or transmit it to such time and place as is desirable to receive from it again the energy given to it, and this without an unreasonable amount of loss of energy. There can be received from it no more energy than has been imparted to it; the great value of air as a power lies in the fact that there is so little loss of energy.

Air is the one substance always present, the supply is inexhaustible, we are living at the bottom of an ocean of air 200 miles in depth; to seize upon and use this substance in our work possesses a fascination of itself. It seems strange that any extensive use of air for storage or transmission of power has come about only in the last few years.

Energy may be imparted to air either by the application of *heat*, or *pressure*. The former is but little used compared with the latter method. It pays to put energy into air by direct heating only when the air is to be applied to do work immediately, as in the case of some hot air engines, and in high pressure air motors. The objection to storing energy in air by giving heat to it is that with the increase of temperature of the air, the loss by radiation and conduction to neighboring bodies is correspondingly increased and it is impossible to prevent consequent dissipation and loss of the heat energy.

The principle of the hot air engine may be briefly stated. The air is heated by contact with a hot iron cylinder or other means, and is thereby caused to expand, acting against a piston which it pushes out against atmospheric pressure. Then by cooling the confined air by water jacket it is caused to contract followed by the piston driven in by the pressure of the outside air.

The application of pressure to air is the common means of imparting energy to it. The effect of the pressure exerted is to compress the air into a smaller volume and to increase its temperature. This volume of compressed air now has energy by virtue of its added pressure and higher temperature, and if allowed to do work will expend both in a return to normal volume, less the losses noted above. If the air is stored the loss of its temperature energy will be considerable, and it is, therefore, desirable that as little energy be stored as heat and as much in pressure as is possible, that is, cooling of the air during compression is desirable. Also the less heat, the less back pressure will be exerted on the piston of the compressor during action. Cooling of the air during compression is attempted either by spraying water into the air or by surrounding it with a cold water jacket. The latter is more efficient where the cylinder is small, thus providing better contact with the air. The spray is objectionable because it renders the air moist and is a detriment in later use. When air is compressed and cooled so that no increase in temperature results during compression it is termed "isothermal compression;" but when all of the heat is retained in the air and both pressure and temperature are increased it is called "adiabatic compression." As a matter of fact neither case is attained in practice because no means are devised whereby all the heat can be either removed or retained under compression. The terms are in general use, however, to express different methods. Because of the expansive action of the heat on the air, in compression, 1 1-3 as much work is needed to compress adiabatically one pound of air from ordinary conditions to a gauge pressure of 90 lbs. per square inch, as would be needed to compress the same isothermically. Therefore, adiabatic compression is uneconomical unless heated air is needed for immediate service in motors.

The cooling of air during compression is largely effected by means of cooling tanks or other devices and the air, after being somewhat compressed, is passed through one of these, thence to a second

compression, and so on. In case the air is compressed in one cylinder only, it is termed a single-stage compressor. If the air is first compressed, then cooled, then again compressed, it is a two-stage compressor. If three cylinders, a three-stage, and so on, the apparatus being named from the number of compressing cylinders or stages of compression. The air is usually cooled between each stage by passing it through "inter-coolers," so called, which are vessels variously constructed so as to expose the heated air to as large a cooling surface as possible, thus bringing its temperature down to as near normal as may be before it enters the next compression cylinder. No one form of these mutiple stage compressors is best for all purposes, the comparative economy being a question of the pressure desired, the use to be made of the air, and other factors largely peculiar to each different plant. The efficiency of a compressor depends largely upon its intercoolers; but every compressor-cylinder and inter-cooler added increases the friction to be overcome by the driving force, and hence increases proportionately the work which the engine must do; hence it is only when the gross saving effected by the addition of another air compression cylinder and an inter-cooler is *greater* than the gross loss due to increased friction and amount of machinery to be driven, that there is any economy in the additional compressor cylinder and cooler.

Air may be compressed by other means, one of which is by the direct action of a waterfall. Wherever possible such means should be employed, but in the vast majority of cases the steam-driven compressor pumps are the best means of air compression. The pressure to which air is subjected varies from one to two ounces per square inch for ventilation purposes, to 2,000 or 3,000 lbs. per square inch for power storage or transmission service. In ventilation large volumes of air are needed under very light pressure, and for this some form of the fan blower is best adapted. For pressures more than a few pounds per square inch, too high for fan blowers but low for piston compressors, the positive rotary blower type is desirable. This form is largely used for blast in forges, forced draught, pneumatic dispatch tubes, and like purposes. In Bessemer steel plants pressures from 15 to 30 lbs. per square inch are generally used and for these and higher pressures up to about 75 lbs. the single stage piston compressor is best adapted. The heating effect on the air at these pressures is quite marked and from above 40 lbs. the question of cooling the cylinder walls becomes an important one with any but very small equipments. For forced draughts the heating of the air is, of course, not objectionable.

From this point on to higher pressures two or three or more compression cylinders are considered more economical. For air drills, mining apparatus, and all the multitudinous applications of compressed air for tools of all descriptions, pressure from 80 lbs. to 90 lbs. per square inch are in general practice, with a tendency developing from experience to increase to 100 lbs. or over, as a working pressure. For all these appliances the air should be as dry as possible and hence it is preferable to avoid the spray of water in cooling at the compressor. The air should also be free from dust and grit to avoid damage from cutting, especially in the drills and motors having a number of small valves and pistons.

For power storage and transmission air from 1,000 to 3,000 lbs. pressure is in demand. Too little is known regarding the most economical handling, transmission and use of the air at these high pressures. For many reasons it is probable that it is more economical to transmit and use air at these rather than at lower pressures.

When the energy stored in the air is finally taken from it, the pressure first communicated to it is given to the various mechanisms provided, and thus it does work. At the same time there is a return to (nearly) original volume and the air now becomes cold. Just as with a decrease of volume heat was developed, so now with the increase in volume, cold is evident. To be more exact, with a diminution of volume or condensation of any gas, heat is liberated, and with the opposite or expansion of the gas, heat is absorbed, evidenced by "cold."

Air being a mixture of gases it may contain varying amounts of its constituents. No trouble is experienced with any of these except the water vapor. When it is chilled sufficiently it changes to solid form and often clogs the exhaust pipes or even the valves of the appli-

ances wherein the air is liberated for use. To avoid this trouble either the moisture must be previously removed or the compressed air heated to a sufficient degree so that in expanding the temperature will not fall below the freezing point of water.

In expansion, as the energy is given up from the air, one cubic foot of air at 60 pounds pressure will expand to 5.10 cubic feet free air; at 80 pounds pressure to 6.46 cubic feet. and at 100 lbs. previous pressure the freed air will occupy 7.82 cubic feet. One pound of air at 60 degrees Fahrenheit when compressed to 1,000 lbs. per square inch would occupy a volume of about one and one-half gallons, and if previously heated can be made to develop in a motor a little over one horse power for three minutes. In this process the air will absorb about 150 calories of heat. Thus a very valuable refrigeration is offered aside from its motive power, and by proper appliances should be, and often is, made use of quite effectively. The cooling effect may be secured and used by water jacket or like device, or the cooled exhaust (and exhausted) air, itself, can be used in many ways. Large advantage is taken of this cooled exhaust air for ventilation purposes and its value is too apparent to need further discussion. Especially is this true in mine work, in submerged caissons, in any enclosed chamber work, and in the hot workshop in summer time it is a boon to the workman. Only in cases where the air is contaminated from the oil used in lubrication in the air machines is it objectionable. One of the most important factors in the use of compressed air for power lies in the fact that the exhaust does not vitiate the air, nor in any way act as a nuisance; on the contrary, it is rather beneficial than otherwise. And at the place where it is used there are no waste products to prove an obstruction, an annoyance or expense for removal. In vehicles of all descriptions, from the heavy compressed air locomotive or surface railroad passenger coach to the lightest running vehicle, compressed air furnishes a power for traction purposes which possesses peculiar advantages. Air motor cars can be compared with accumulator cars for independence and silent running, and have none of their drawbacks except weight. They possess the elasticity of power of steam vehicles with none of their objections on the score of noise, exhaust and fuel handling. Compared with the trolley, air cars are equally powerful and do not necessitate installation of head or surface connections, and are not liable to the trolley limitations and exasperations. While it is unnecessary and not pertinent to disclaim against other motor powers in favor of air, certainly each have advantageous qualities over the others, and air has points in its favor which recommend it. It has an advantage over electricity in that it is safe and harmless, no danger of electric shock or fire through defects or accidents in wiring or use; once compressed, it is ever available whether compressor happens to be running or not, and when not wanted there is no expense and no loss concerned with keeping it constantly and instantly available. Other advantages might be used, but limited space precludes such discussion, as well as any entrance into detail or even mention of the several thousand and one uses which have been found for compressed air. And no matter how complete such a list of uses might be prepared, it would be incomplete and out of date before the printer's ink were dry on the page.

Air supports our life, the life of all animate nature; it is equally ready to be harnessed and thus to do our bidding in countless details of daily duties. It will clean our garments and finest carpets and tapestries in their place, noiselessly and without a whiff of dust; it serves to harden the quicksand and make ready the foundations for great engineering structures; it takes earth's treasures from the mine, opens the way for rapid transit through mountains or under the crowded city streets and blocks of buildings; affords safe transit, or, rather, *safe stoppage* by the automatic air brake; carries our packages, transmits our mail; in short, helps amazingly to make life safe and comfortable, allowing one man to do the work of ten and permitting to each a greater measure of economy in time and in effort.—George Platt Knox, in *The Economist.*

## The Imperial Type of Air Compressor.

The accompanying half-tone and line engravings illustrate a new type of air compressor which has been introduced re-

cently by the Rand Drill Company, of 128 Broadway, New York, and which is intended more especially for shop use. The air cylinders are fitted with positive moving Corliss inlet valves and are compounded, the intercooler being in two sections which are placed in the bases.

An interesting and novel feature of the machine is the method of securing flooded lubrication of the various bearings. The splash method of throwing the lubricant from the crank case is not applicable to air compressors on account of the slow speed at which they at times operate. A compressor must of necessity operate at various speeds to meet the constantly varying demand for air. While the higher speeds may be sufficient to throw the oil in the manner employed in enclosed crank case engines, the lowest speed, which is usually set to be the slowest at which the machine will turn over without catching on the center, would be entirely insufficient and at times when but little work is being done, the machine may operate so long at this slow speed as to make it unsafe to depend on the oil thrown at previous higher rates of speed.

This difficulty is met in a very neat way which we believe is new. Each bed is so formed as to provide an oil cellar, the top of which is so located that the crank disks dip into the oil, which oil will obviously be carried around by the disks at any speed. The direction of the motion is "over" and a light scraper *a*, Fig. 2, scrapes the oil from each disk and delivers it into the channel *b*, which is elevated above the highest bearing and from which it is carried by suitable pipes and channels to the various bearings. Such pipes and channels will be seen at *b*, *c* and *d*.

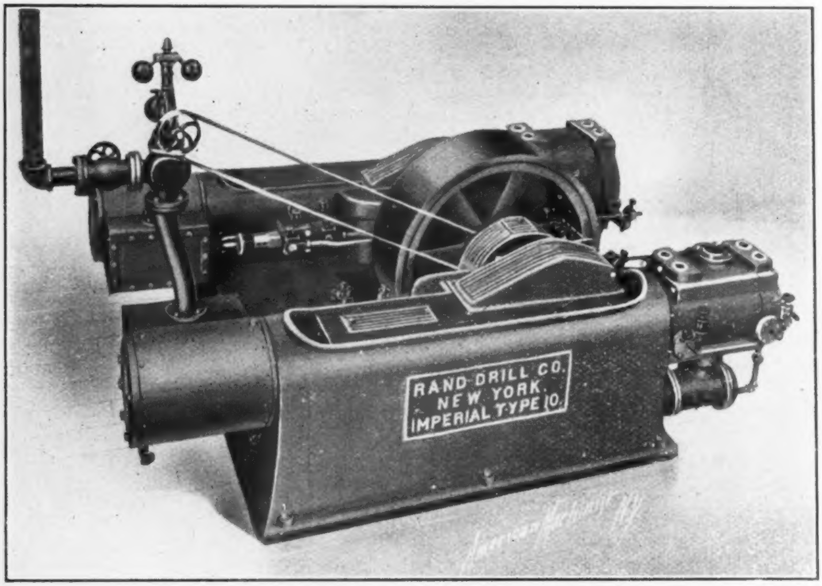



FIG. I. THE IMPERIAL TYPE AIR COMPRESSOR.

The design will be seen to be somewhat bold in that the air piston rod is, in plan, offset from the steam rod. To counteract the effect of this the crosshead is made of unusual length and its sliding surface is formed into a series of V-grooves which fit corresponding grooves in the guide. The downward thrust of the connecting

rod forces the crosshead to travel in these grooves in a true straight line and in addition to this the air piston rod will be seen to be, from necessity, of considerable length, giving ample opportunity for spring should it be needed. Large numbers of these machines are running and we are informed that no difficulty has developed from this source. It appears to be a case of "handsome is as handsome does," for certainly the advantages of the arrangement in point of compactness are very apparent.—*American Machinist.*

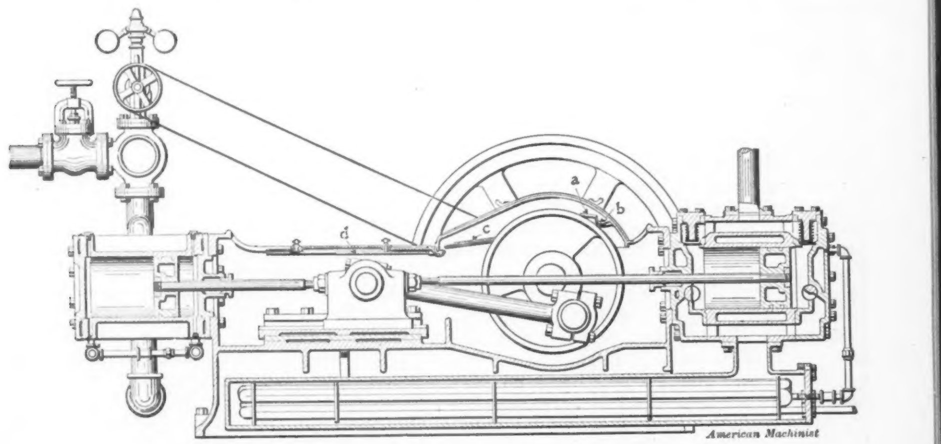



FIG. 2. LONGITUDINAL SECTION OF THE IMPERIAL TYPE AIR COMPRESSOR.

## The Freezing of Moisture Deposited from Compressed Air.

The presence of moisture in compressed air must be accepted as an unavoidable condition. Existing in the atmosphere at all times, in greater or less quantity, when air is compressed the moisture is carried with it. In practice, a part of the water is deposited in the air receiver; but a considerable quantity still remains, and will be brought into evidence when the proper conditions occur.

The capacity of air for moisture depends primarily upon its temperature. Under ordinary atmospheric conditions, 1,000 cubic feet of air contain about 1 pound of water. When compressed in the compressor cylinder the increase of heat which takes place augments the moisture-carrying capacity of the air. But the moisture-carrying capacity is reduced by any subsequent decrease in temperature, and if the air be saturated the excess of moisture is deposited. Volume for volume, the capacity of air for moisture is independent of its pressure or density. That is, at the same temperature, a cubic foot of air at atmospheric pressure will hold in suspension the same weight of water as a cubic foot at 100 lbs. pressure. But this must not be misunderstood. If a certain volume of moist atmospheric air be compressed isothermally, that is, at constant temperature, say to one-tenth of its original volume, its water capacity is also reduced to one-tenth, and nine-tenths of the water originally present in the air is deposited. Therefore, while the water capacity of a given volume of air varies with the temperature, it must change also with any increase or decrease of the pressure which changes its volume.

Certain conditions are required to cause freezing: deposited moisture must be present, and it must be subjected to a temperature below the freezing point. So long as the temperature does not fall low enough the presence of moisture can do no harm. Although one of the recognized functions of the air receiver is to permit the deposition of water before the

air passes into the pipes, still, unless the receiver be extremely large, the air leaves it warm—usually even quite hot—and therefore carries with it considerable moisture.

Unless liberal sprays are used to attain effective cooling, the air from wet compressors is apt to contain more moisture than that from dry compressors. A well-designed injection compressor, however, not too small for its work, and therefore running at a moderate speed, will deliver cool air which will not give trouble from freezing. Being thus well cooled on entering the pipe line, even though it be nearly if not quite saturated, the moisture-carrying capacity of the air is not greatly reduced by passing through the pipe, and but little further deposition of water takes place. With dry compression, the percentage of humidity of the intake air, and the temperature at discharge, determine the quantity of water carried out of the cylinder. The humidity, in turn, varies with the weather. Changes in the weather may be quickly followed by variations in the quantity of moisture deposited from compressed air. When the air is finally expanded in doing its work intense cold is produced as the pressure falls and the latent heat of compression is absorbed. It is here that the moisture carried with the air into the pipes makes its appearance as frost and causes trouble.

The difficulty which may arise from this state of things is apt to be exaggerated. That freezing not infrequently occurs is true, but with a properly arranged plant it may be easily avoided. Two things require attention: first the air should be caused to drop its moisture as completely as possible before entering the main; second, provision should be made for draining off what deposited moisture remains in the pipe line before the air passes to the machine in which it is to be used. Although this is a simple matter, the means for accomplishing it are often neglected. Considerable quantities of water may collect in low places in the pipe line, and, if not blown out at intervals, will be carried into the ports, cylinder and exhaust passages of the air machine, and there freeze.

Granting that the air leaves the receiver near the compressor practically saturated and still warm, it is evident that a great improvement in working may be realized by introducing a second receiver as near as possible to the machines using the air. In mining, the second receiver is, of course, placed underground. Before reaching it the temperature of the air will have become normal, and the entrained moisture from the pipe line may be conveniently trapped and drawn off. Automatic water traps are preferable to valves or cocks for getting rid of the water.

The statements made above suggest an important consideration, viz., in transmitting power by air at a high pressure there is less liability to trouble from freezing than when low pressures are employed; provided, that the length of pipe line is sufficient to allow the air to be completely cooled and drained of its water while still under high pressure. At a low pressure a greater volume of air is required to furnish a given amount of power than when at a high pressure. More moisture must therefore be dealt with, and at the low pressure it cannot be so thoroughly separated before the air is used. Suppose, now, the transmission is at a high pressure, and through a pipe long enough to allow the air to reach normal temperature. If the deposited moisture be drained away while the air is at its maximum pressure, then, if the air be subsequently expanded down to a lower pressure suitable for working (with a corresponding increase of volume), and allowed to regain its normal temperature, the percentage of moisture in the larger volume is reduced, so that the air may be relatively very dry. When finally used in the air engine, there will not be enough moisture present to cause troublesome freezing.

At the Drummond Colliery, Nova Scotia, for running an underground pump by compressed air two receivers are used, one near the pump and another 300 feet farther back on the pipe line. The air pressure in the main from the surface is 85 pounds, and as the proportions of the cylinders of this particular pump are such that so high a pressure is unnecessary, a reducing valve was put in the pipe just before reaching the first receiver. By this valve the air is wire drawn to reduce the pressure to 45 pounds, which results in a deposition of nearly one-half the entrained water, in addition to that already deposited in the pipe. It is found that more moisture collects in

the first than in the second receiver (as might be expected), and by this device the serious difficulty previously encountered from freezing at the pump has been entirely overcome. The temperature lost by the reduction of pressure to 45 pounds is regained before the air reaches the pump.

What precedes refers to the freezing produced by internal reduction of temperature, acting upon the moisture carried in the air. In using compressed air, even for mining purposes, it often becomes necessary to carry lines of air pipe considerable distances on the surface. To prevent condensation and freezing of the moisture in winter by external cold all surface piping must be protected. If exposed to temperatures below the freezing point the inner surface of the pipe will become coated with ice, and its effective cross section reduced. A serious diminution of area may thus be caused at low points in the pipe line, where water tends to collect; or the pipe may even be frozen solid in such places by the gradual accumulation of ice. Underground the temperature is rarely, if ever, low enough to render any protection necessary, except in winter, in cold down-cast shafts.

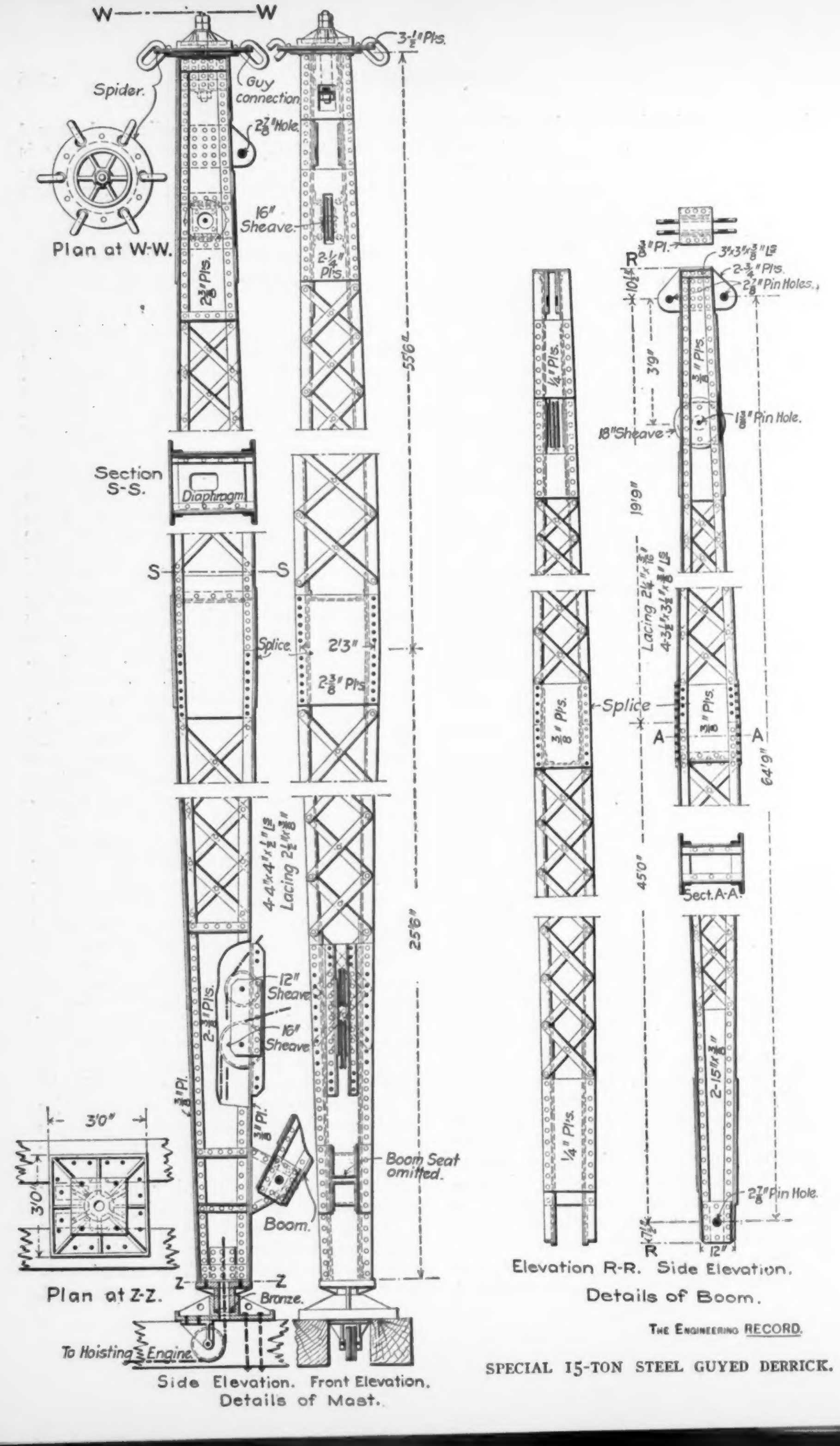
Some time ago, at the Anaconda copper mines, Butte, Mont., (as stated in COMPRESSED AIR), a simple and inexpensive device was installed to prevent the freezing of the moisture in a long line of surface piping. From one of the large compressor plants the air main was carried on the surface a long distance before reaching the shaft. During the winter months it was at times difficult to get sufficient air pressure in the mine, because of the partial choking up of the pipe. As the volume of air was too large to be dealt with by the ordinary receiver, a series of old boilers was put in close to the compressor house. The hot air, at 80 pounds pressure, in passing through these boilers, from one to another, was cooled down practically to the temperature of the atmosphere, and as a consequence a large part of its moisture was deposited. It was found that old tubular boilers, when strong enough, are well suited to this purpose, because of the large surface presented to the cold outside air, especially when they are set horizontally, so that there is a free circulation of air through the tubes. A blower might be used for the same purpose or the boilers submerged in cold water. This effectual remedy is well worthy of imitation where the conditions are similar—Robert Peele, in *Mines and Minerals.*

## The Construction of the Hanover Bank Building, New York.

The new Hanover bank building at Pine and Nassau streets, New York, is a twenty-two story steel-cage structure. Before the old buildings were removed from its site preparations for its construction were commenced by sinking half a dozen test holes in their cellars without disturbing the tenants. These holes were jetted down about fifty feet to the hardpan and indicated that the latter had an approximately horizontal surface and was overlaid with quicksand. It was determined to support the building on concrete foundations carried down through the hardpan to solid rock by the pneumatic caisson process, and the contract for the substructure was let to Mr. John F. O'Rourke, M. Am. Soc. C. E., who commenced operations in November, 1901.

The old building was removed and the site excavated to a depth of about 23 feet below the curb or 1 foot above water level. The walls of the adjacent buildings on Nassau and Pine streets were underpinned by 19 vertical cylinders sunk by the Breuchaud process to hardpan, filled with concrete, and wedged up under the wall. These cylinders were made of sections of 16-inch steel pipe joined together with outside screwed sleeves, and were sunk under the centre line of the wall by a powerful hydraulic jet and a hydraulic jack reacting against horizontal beams recessed into the outer face of the wall a few feet above the footing. The pipes encountered no boulders. When they arrived at the hardpan they were pumped dry and a quantity of dry concrete was placed in the bottom; then the pipes were filled with ordinary 1:2:4 Portland cement concrete dumped from the top and rammed in the upper part.

Operations were not fairly under way on the main foundations until the middle of December, when they were prosecuted with great vigor and all were sunk within a remarkably short time. The 40 main columns are supported on 6 rectangular and




SPECIAL 15-TON STEEL GUYED DERRICK.

27 circular piers, each of which is built inside a pneumatic caisson and cofferdam. The arrangement and relative sizes of the caissons are shown on the foundation plan published with the previous description of this building. The cylindrical caissons vary from 6 feet 8 inches to 11 feet 8 inches in diameter, and the rectangular ones are, with one exception, 6 feet wide and from 16 to 31½ feet long. All of them were built with 4 x 12-inch vertical wooden sheathing planks on steel angle frames. The cylindrical caissons were made continuous with their cofferdams, and were received at the site in lengths up to 32 feet. The rectangular caissons were received in sections 18 feet high, which were bolted together through inside flanges.

The rectangular caissons are set so as make a continuous wall across the sides of the lot opposite the street fronts, and not only serve to support the wall columns but form a solid concrete dam from bedrock to above water level, which is watertight and resists any external pressure from the quicksand or ground water. These caissons were of special pattern, similar to those used in the new Stock Exchange foundations. Semi-cylindrical shafts were left open in the adjacent ends of the cofferdams on top of the rectangular caissons until after they were concreted, when the end walls of the cofferdams at the shafts were removed to form oval wells which were filled solid with rammed concrete making vertical keys, 4 feet in diameter; these keys reached from the top of the pier to the roof of the working chamber and bonded the sections of the wall or dam together with water-tight joints. These keys penetrated several feet into the hardpan and were considered ample without making connections between the ends of the working chambers as was done in the Stock Exchange work, where the cellar excavation was practicallly to the bottom of the caisson.

At the commencement of operations a raised movable platform 40 feet long, reaching from the edge of the excavations to the opposite curb, was built of heavy timber and supported two 20-ton stiff-leg derricks, hoisting engines and some supplies and machinery above Nassau street without obstructing the traffic there.

Near the middle of the Pine street front a platform was built at street level half way across the excavation, parallel to Nassau street. It had a 4-inch timber deck about 28 feet wide and was supported on frame bents of 12 x 12-inch timber about 24 feet high. On it was a longitudinal track for a traveling tower which had four vertical corner posts and was braced in the six vertical and horizontal faces with pairs of diagonal screw-ended rods. The vertical posts were braced at the tops by diagonal posts in the four sides and served as masts for four derrick booms about 50 feet long. After setting four cylindrical caissons beyond the end of the platform, the falsework was extended above them across the full width of the lot and the derrick tower traveling back and forth on it, was able to command all the site execpt what was served by the Nassau street derricks. Holes were cut through the platform to set the caissons under the place where the derrick tower was at first placed, and shelters for the air compressors, workshops and other sheds were built at convenient places where they would clear the caissons. Each derrick boom was operated by a separate Lidgerwood hoisting engine, which swung it horizontally by a bullwheel attached to the foot of the mast.

Including those which were being concreted, as many as five or six caissons were under air pressure at once and as many as four were usually being sunk simultaneously. They were sunk to a total depth of 75 to 81 feet below the curb. The first 40 feet was in quicksand through which the cylindrical caissons were sunk in about 24 hours and then an average of 48 hours more was required to sink them through 12 to 24 feet of hardpan to the solid rock. The last caisson was concreted on February 5, and the erection of the steel superstructure was commenced soon afterwards, while the excavation of the cellar was continued to about 4 feet below the water level.

Our frontispiece progress view is made from a photograph looking towards Pine street and showing the foundation work in full operation on January 8, 1902. In the foreground, on the right, is shown the air lock and shaft rising from a cylindrical caisson which is sunk out of sight; beyond it two more cylindrical caissons are being sunk and have cofferdams on top which reach above the curb level. In the background is the falsework

platform with the tower derrick at the left, ready to hoist one section of the cofferdam of a rectangular caisson. A working platform for the calkers is suspended from the upper edge of the cofferdam, and at the right there is the caisson or lower section of a wall-pier shell. These foundations included more than 6,000 cubic yards of caisson work, which was executed within two months during the winter. Mr. O'Rourke has made very rapid progress with similar work, which has been described from time to time in these columns, but this is believed to establish a record for speed in caisson sinking; he attributes it to thorough preparation and organization, together with the special caissons and equipment employed. —*Engineering Record.*

## Hot Air Engines.

People are so used to steam and gas engines that the old, reliable and economical user of coal for pumping purposes is forgotten, and in many cases where it should be best known, it is altogether unknown. I refer to the hot air engine, sometimes, though erroneously, called a caloric or heat engine. Strictly speaking it should be called an external combustion engine to distinguish it from that class of engines in which the combustion which supplies heat occurs within a closed chamber containing the working substance. The ordinary coal gas explosive engine is the most common type of internal-combustion engine.

Compared with an engine using saturated steam, air and gas engines have the important advantage that the temperature and pressure of the working substance are independent of one another. Therefore, it is possible to use an upper limit of temperature greatly higher than in the ordinary steam engine, and if the lower limit is not correspondingly raised, an increase of thermodynamic efficiency results. It is true that the same advantage might be obtained in the case of steam, by excessive superheating, but this would mean, substantially, the conversion of the steam engine into the type we are now considering, the working substance being then steam gas. The action of the air engines, like that of all other heat engines, consists in admitting the air at a high temperature and pressure, worked expansively, and then it is either exhausted into the atmosphere and a fresh supply introduced, or it is again heated and compressed for a repetition of the former process. In the cycle just described, air has some advantages over steam as a working fluid. The efficiency of an engine depends upon the limit of temperature to which the working fluid is subjected, and it is practicable to use a higher working temperature with air than with steam, because there is no fixed relation between the temperature and pressure of air, as exists in the case of steam.

In the actual forms in which Stirling's engine was used, the most important feature was that the air was compressed (by means of a pump) to a pressure greatly above that of the atmosphere. Stirling's cycle is theoretically perfect, whatever the density ot the working air, and compression in this case did not increase what may be called theoretical thermodynamic efficiency. It did, however, greatly increase the mechanical efficiency, and what is of importance, it increased the amount of power for a given size engine. To see this it is sufficient to consider that with compressed air a greater amount of heat is dealt with in each stroke of the engine.

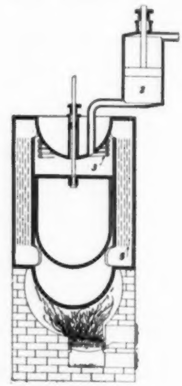


Fig. 1.

The Stirling engine is diagramatically shown in Fig. 1. The several parts are: 1 is a closed vessel containing air externally heated by a furnace beneath it. A pipe from the top of one leads to the working cylinder 2. At the top of 1 is a

refrigerator 3, consisting of pipes through which cold water circulates. In 1 there is a displacer plunger 4 (or transfer piston), which is driven by the engine; when this is raised the air in 1 is heated, whereas when 4 is lowered the air in 1 is brought in contact with the refrigerator and cooled. On its way from the bottom or top, also on its way from top to bottom, the air must pass through an annular lining of wire-gauge 5. This is the regenerator. At the beginning of the cycle 4 is up. The air is then receiving heat and is expanding isothermally; this is the first stage. Then the plunger or transfer piston 4 descends. The air is driven through the regenerator 5, where it deposits heat, next the working piston makes its down stroke (in the actual engine the working cylinder was double acting, another heating vessel, precisely like 1, being connected with the upper end of the working cylinder). This compresses the air isothermally, the heat produced by compression being taken up by 3. Finally the plunger 4 is raised, and the working air again passes through the regenerator, taking up the heat it left there.—A. Edward Rhodes, in *Practical Engineer.*

## Lubrication of Air-Pump Air Cylinders.

Air-brake men for some time have realized that air cylinders of air pumps have not been lubricated in the proper manner. The common way of oiling the pumps, through the cock on the air cylinder, proved itself to be inefficient and did not produce as good a result as could be desired. When oiling this way, too much oil was generally put in at one application, and before receiving the next dose the cylinder would become dry, causing excessive wear and requiring frequent boring of the cylinder and renewal of piston packing rings, and all the other numerous evils attending badly worn cylinders and leaky piston packing.

There can be no doubt that the air cylinders of our air pumps, which nowadays are generally worked to their utmost capacity, need constant lubrication in proper quantity. This evil has been successfully overcome by Master Mechanic W. S. Clarkson, of Livingston, Mont., who has applied a lubricator to the air cylinder of the air pump. This lubricator consists of a plunger-feed rod cup, which is applied to the air cylinder, by tapping a hole in the wall of the air cylinder, midway between the top and bottom heads. Into this hole an elbow is screwed, so as to hold the cup in a vertical position. The hole in the wall of the air cylinder, just before reaching the inner surface, is reduced to 1-16 inch.

The feed of the cup is regulated by reducing or increasing the lift of the plunger, which is done by a set-screw in the top of the cup. These cups may be so regulated as to feed any quantity of oil desired. They have been in use on the Montana division of the Northern Pacific Railroal for five months, and have been used on pumps engaged in the most severe kind of service. Examination of the air cylinders has shown that the wear has been reduced to a minimum by a small quantity of oil fed continuously to the air cylinder of the air pump. It is found to be a great improvement over the old way of oiling the air cylinder. This device is simple and inexpensive and results in a great saving to the air pump as well as economy in oil. This may be a device used before, but it has never been brought to my notice.—C. E. Allen, in *Railway and Locomotive Engineer.*

## Compressed Air for Pumping Plants.

For convenience in figuring on large pumping plants to be operated by compressed air, there is given herewith a table by which the pressure and volume of air required for any size pump can be readily ascertained. Reasonable allowances have been made for loss due to clearances in pump and friction in pipe.

To find the amount of air and pressure required to pump a given quantity of water a given height, find the ratio of diameters between water and air cylinders and multiply the number of gallons of water by the figure found in the column for the required lift. The result is the number of cubic feet of free air. The pressure required on the pump will be found directly above in the same column.

For example: The ratio between cylinders being 2 to 1. Required to pump 100 gallons, height of lift 250 feet. We find under 250 feet at ratio 2 to 1 the figures 2.11; 2.11 x 100 = 211 cubic feet of free air. The pressure required is 34.38 pounds.

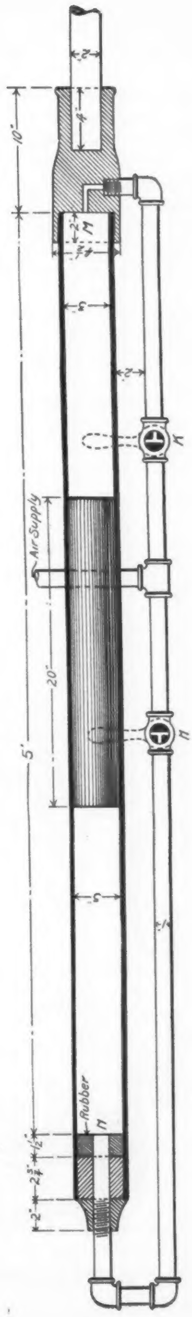
| Ratio of Diameters. | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 300 | 350 | 400 | 450 | 500 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PERPENDICULAR HEIGHT, IN FEET, TO WHICH THE WATER IS TO BE PUMPED. | | | | | | | | | | | | | | | |
| 1 to 1 | 13.75 | 27.5 | 41.25 | 55.0 | 68.25 | 82.5 | 96.25 | 110.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Air pressure at pump. |
| | 0.21 | 0.45 | 0.60 | 0.75 | 0.89 | 1.04 | 1.20 | 1.34 | ..... | .... | ..... | ..... | ..... | ..... | ..... | Cubic feet of free air per gal. of water. |
| 1½ to 1 | ..... | 12.22 | 18.33 | 24.44 | 30.33 | 36.66 | 42.76 | 48.88 | 55.0 | 61.11 | 73.32 | 85.4 | 97.66 | ..... | ..... | Air pressure at pump. |
| | ..... | 0.65 | 0.80 | 0.95 | 1.09 | 1.24 | 1.39 | 1.53 | 1.68 | 1.83 | 2.12 | 4.41 | 2.70 | ..... | ..... | Cubic feet of free air per gal. of water. |
| 1¾ to 1 | ..... | ..... | 13.75 | 19.8 | 22.8 | 27.5 | 32.1 | 36.66 | 41.25 | 45.83 | 55.0 | 64.16 | 73.33 | 82.5 | ..... | Air pressure at pump. |
| | ..... | ..... | 0.94 | 1.14 | 1.24 | 1.30 | 1.54 | 1.69 | 1.84 | 1.99 | 2.39 | 2.59 | 2.83 | 3.19 | ..... | Cubic feet of free air per gal. of water. |
| 2 to 1 | ..... | ..... | ..... | 13.75 | 17.19 | 20.63 | 24.06 | 27.5 | 30.94 | 34.38 | 41.25 | 48.13 | 55.0 | 61.88 | 68.75 | Air pressure at pump. |
| | ..... | ..... | ..... | 1.23 | 1.37 | 1.52 | 1.66 | 1.81 | 1.96 | 2.11 | 2.40 | 2.69 | 2.98 | 3.28 | 3.57 | Cubic feet of free air per gal. of water. |
| 2¼ to 1 | ..... | ..... | ..... | ..... | 13.75 | 16.5 | 19.25 | 22.0 | 24.75 | 27.5 | 33.0 | 38.5 | 44.0 | 49.5 | 55.0 | Air pressure at pump. |
| | ..... | ..... | ..... | ..... | 1.533 | 1.68 | 1.83 | 1.97 | 2.12 | 2.26 | 2.56 | 2.85 | 3.15 | 3.44 | 3.73 | Cubic feet of free air per gal. of water. |
| 2½ to 1 | ..... | ..... | ..... | ..... | ..... | 13.2 | 15.4 | 17.6 | 19.8 | 22.0 | 26.4 | 30.8 | 35.2 | 39.6 | 44.0 | Air pressure at pump. |
| | ..... | ..... | ..... | .... | ..... | 1.79 | 1.96 | 2.06 | 2.104 | 2.34 | 2.62 | 2.88 | 3.18 | 3.36 | 3.23 | Cubic feet of free air per gal. of water. |

COMPRESSED AIR FOR PUMPING PLANTS. (See page 1810.)

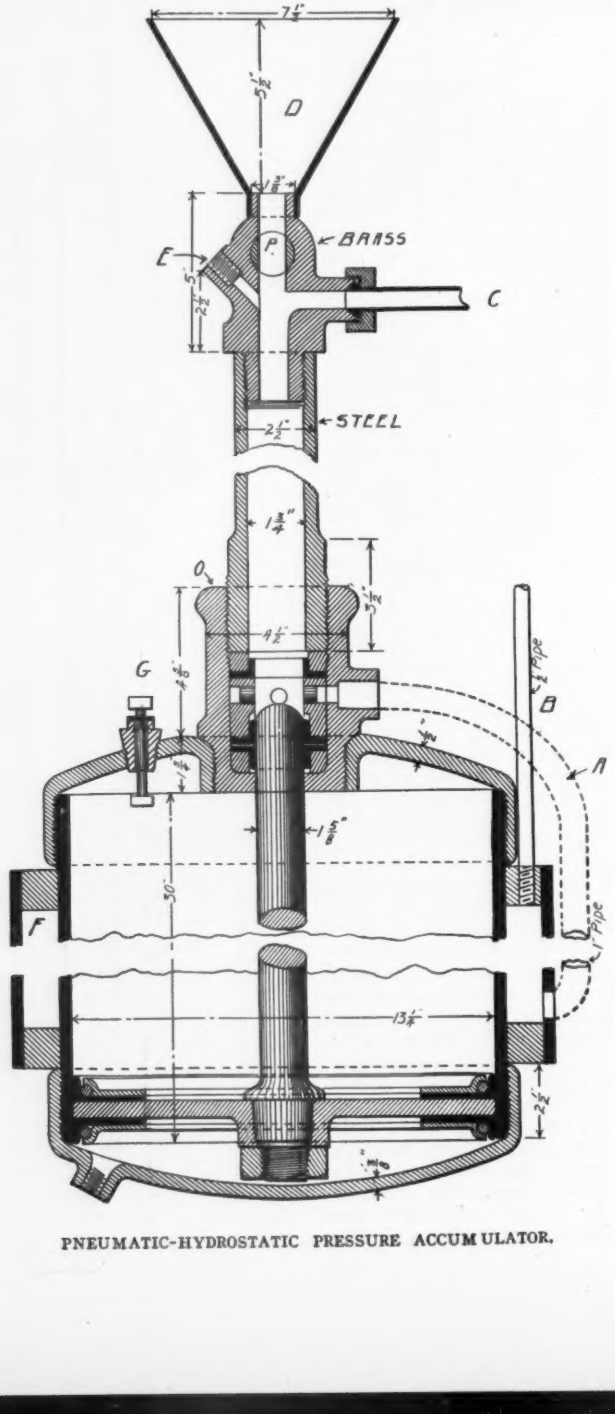
## Two Useful Pneumatic Tools.

Compresed air tools have accomplished much in the way of expediting work in many lines of industry. This is especially noticeable in the application of pneumatic tools for repair work such as must be encountered in railroad shops. The character of the work in the boiler and smith shops naturally affording a greater field to test the utility of such tools, it is here that they are found to be the most useful.

The accompanying illustrations show a pneumatic-hydrostatic pressure accumulator and a pneumatic hammer invented by Alfred Parfitt, foreman boilermaker in the Topeka shops of the Atchison, Topeka and Santa Fe. The hydrostatic machine is patented, the latter is not. The pneumatic hammer is a particularly convenient all-round tool. The device may be made any size to suit the work in hand. It can be cheaply constructed and a laborer can, with a little practice, become expert in handling the operating valves. The main cylinder in this case is made of 3-inch wrought iron pipe, 5 feet long. A plug is welded in the one end, as shown. Originally this plug was screwed in, but the knock of the hammer, due to the return stroke, soon resulted in injury to the thread, although the impact was on the rubber cushion. The plug in the opposite end or tool holder is screwed on, as the full force of the blow is transmitted directly to the work through the medium of the tool resting in the socket at its outer end. The hammer, which is 20 inches long and weighs about 40 pounds, is operated by two plug valves, H and K, with the arrangement of piping, as shown. These valves are drilled to operate as a three-way cock, and by turning the handle K so that the port stands lengthwise to the pipe, air is admitted through the contracted port opening M, and the hammer is driven to the opposite end of the cylinder. The valve is then returned to the position shown in the cut and the valve H opened. The opening, N, being large, offers little resistance to the flow of air, and the hammer is driven to the other end of the cylinder with great force. The cylinder is supported by block and tackle and preferably held to the work with a slightly




A PNEUMATIC SLEDGE HAMMER.




PNEUMATIC-HYDROSTATIC PRESSURE ACCUMULATOR.

downward inclination of its forward end. This tool has been found particularly useful in breaking stay-bolts in fire-box legs that are inaccessible with the ordinary stay-bolt breaker. It is also used for cutting off rivet-heads in fire-box sheets and one blow is sufficient to cut off crown-bar nuts and heads. A shorter arrangement of this same tool is used for heading crown-bar bolts, by means of a concave tool placed in the socket. In fact, the tool may be put to many uses in and around the boiler shop and three men will perform as much work as six men with ordinary appliances, where the character of the work demands heavy sledging.

The pneumatic-hydrostatic pressure accumulator here shown was made primarily to be used for punching sheets in repairs to fire-boxes and boilers where operation is necesary without removing the sheets. The device is mounted on a truck and may be moved near the work in hand. The main cylinder is 13¼ inches in diameter and is made of cast-steel having flanged heads on either end. Around the outside of the cylinder is a water space F. A stuffing box O is screwed into the top head, which is flanged inwardly to provide for the thread. A steel cylinder is again screwed into this, which is surmounted by a brass cap containing an ordinary plug valve P. C is a ⅜-inch copper pipe which leads to the punch, which is not shown, being the ordinary form of small jaw punch having a 4-inch plunger and capable of being easily handled by the workman. To place the machine in condition for operating the valve P is opened and the upper cylinder or steel pipe is filled with water through the funnel D, the pipe A furnishing means to fill the space F surrounding the main cylinder. The valve P is then closed. A slight auxiliary pressure is necessary to bring the punch to the plate each time before punching, and this is accomplished by turning the air pressure into the ½-inch pipe B by means of a small plug valve connected with the main pressure pipe. This places a pressure on the water in the receiver F and brings the punch to place on the work. Air is then turned in at the bottom of the large piston which forces the 1⅝-inch ram above the openings leading to pipe A, as shown, thereby relieving the auxiliary cylinder of excessive pressure. The ram is then forced through the pipe C, the pressure, of course, depending on the amount of air pressure used. The valve G is used as an indicator in order that the operator may know that he is receiving the full pressure at all times, and that the piston is not in contact with the head. A pressure gauge may be connected at E, which would also serve the same purpose. With 100 pounds pressure on the large piston, using a 4-inch diameter plunger in the punch, a pressure of about 40 tons is available.

This machine will readily punch 1-inch holes in ½-inch and 9-16-inch steel plate, and is very convenient from the fact that it may be used in any portion of the shops and is not a very expensive tool to construct in view of the results obtainable by its use.—*The Railway Age.*

## The Use of Compressed Air in Mining.

Compressed air, as employed in mining, is one of the very few sources of industrial power to which scarcely any exception can be taken. Its advantages—putting aside for a moment questions of comparative cost—are so very obvious that it seems almost loss of time to refer to them, yet it is still in its infancy. It has been in various half-hearted ways partially adopted as a mining motive power for, at least, fifty years past. The slow development of its usefulness is explainable on several grounds. Like every other motive power. it requires time to work out the best results. It is said to be expensive; this we shall deal with presently. A good manv mistakes have been made in installing it which have operated against it, and, lastly, the installers are not wholly free from blame. Mining engineers as a bodv are practical men and not much given to studying theory. Some wholly despise it: others lack the necessary application. and this is scarcelv matter for surprise, for a mine engineer's work is eminently that of a practical man born and bred to it and who has to rely mainly on experience, for with the general working of a mine theory has verv little do and we can hardly blame the engineer for taking little account of it.

But mining, like other industrial enterprises, is fast becoming dependent upon advanced knowledge and ideas, and the

rising generation of mining engineers will find it greatly to their advantage, in fact, absolutely necessary, to study theory and science to keep somewhere near the front, for methods and appliances are fast coming into use which require something more than mere experience, which are, in fact, ahead of experience and therefore demand insight and adaptability of a high order.

In this connection we may mention besides compressed air, electricity and oil gas motors and the employment of machinery in haulage, pumping and getting. ventilating, holing and driving.

We propose to deal here with one only of these modern improvements, compressed air and its applications and advantages.

Its special advantages may be worth repeating here, though every engineer ought to be familiar with them.

1. It can be taken by pipes to any point and used there expansively, just the same as steam and in the same engines.

2. The pipes and the air are cool and the air loses nothing by transmission, except by leakage and a slight drop of pressure from friction in transit.

3. The exhaust is cold, invisible and wholesome, being free air at a low temperature, which may be much below freezing point; a welcome help to ventilation.

4. The engines, being cool, are easy to lubricate and to handle.

5. The air does not corrode the pipes internally.

6. None of the compressing plant need be in the pit—in fact, it is almost always at bank.

7. The cost of it can be kept down easily to that of steam as a motive power if properly installed.

For a moment let us see how this compares with steam, electric, or hydraulic power.

Steam requires boilers, usually below ground. These introduce heat where it is already too hot, the steam pipes and motors are hot, their exhaust is a cloud of hot steam, slow in dispersing and condensing; in fact, impossible to use in detail in the headings and roads for haulage and pumping. Steam engines are, therefore, only usuable near the upcast shaft where the heat and exhaust can be got rid of.

Electricity is many respects a promising rival of compressed air, but only in unfiery mines. It has several very serious disadvantages. These are—apart from its cost, which is high—sparking of dynamo motors, danger of short circuiting from accidental causes very common in mines, high speed of motors, necessitating great reduction by gearing. The motors are too easily injured by unskilled labor and too easily overloaded. There is at present no sign of overcoming these faults, the first two of which are practically prohibitive as far as coal mines are concerned.

Hydraulic power is non-elastic and quite unsuited to general driving of machinery even above ground. It is very wasteful in use, not having the expansive economy of steam or air, and miners do not like any influx of water into a pit, for though it is cheaply pumped to bank by the mine pumping engine, yet the danger from water is such an ever-present one that nothing would induce men to use it as a general source of power.

Oil engines are being proposed for mining purposes and may have some useful, if limited, applications; but petroleum is a dangerous fluid in a mine, and the flame from igniters and vaporizers will entirely prevent their use in coal-pits.

There is, therefore, no effective rival to compressed air for general motor purposes in a pit.

Air is cheap enough as a motor fluid and miners are always ready for any quantity of it, but to use it economically it must be compressed to about the same pressure as steam is ordinarily used. Sixty to 80 lbs. per square inch are ordinary pressures which can be dealt with by the ordinary commercial engines without any special attachment or design. Steam, however, is now used at much higher pressures, 100 to 180 lbs., or more, being common. But such pressures require extra strength in every part and greatly increase loss by leakage and condensation.

In the case of air, the cost of compression and the loss of steam by heating of the air by compression increase very rapidly with the pressure, so that these higher pressures are not at present economical. They require extra strength in the pipes and better joints also; better, in fact, than any now in use, so that until improvements can be effected in the com-

pressor by which the higher pressures can be economically produced and a good pipe joint devised, to prevent leakage, it is not advisable to increase the working pressure much above 60 lbs.

A compressed air plant consists of boilers, air compressing engines, receiver or air vessel, air mains, branch mains, pipes, valves and air engines.

The character and arrangement of the plant will depend much upon the kind of mine and the work to be done below. In many mines there is no rock work, but much hauling, and in many cases driving power is required for coal cutting machines, fans, etc.

In the interests of humanity, hauling ought to be done entirely by engine to save the pony and boy, who are both quite out of their natural element in a pit. The boy ought to be at school or at out-door work, and the pony working on the road.

In designing a compressed air plant the proper course to pursue is first to set out a list of all the motors required, their indicated horse-power, the number of hours each is expected to be at work whether continuously or at intervals. From this list the maximum h. p. demanded at any one time can be deduced.

In estimating this maximum h. p. the character of the motors must be considered. Some engineers think that any kind of a rough made strong engine is good enough in a pit. But this is a serious error. A pit air motor ought to work with the highest possible economy. This is obtainable without any fancy expansion gearing or expensive and complicated valve gear, by using a cut-off slide valve. No engineer should be satisfied with an engine that will not work up to a six to ten-fold expansion. The saving in a good engine from this cause alone may amount to from 10 to 40 per cent.

A high expansion, however, unless the air is heated, produces a very cold exhaust, and unless the air is dry, the exhaust passage may get blocked with ice. This can be avoided by making these passages large, short and direct.

Coal is, of course, cheap at a colliery, and it might be supposed colliery managers would be careless of such minor savings; but coal is coal, and has to be paid for even in a colliery; dividends have to be looked to also. Power is always a dead horse to the mine-owner, and its economical use makes all the difference and bulks very largely on the wrong side of the yearly balance sheet.

But, having estimated the net maximum h. p. required in the pit, a percentage must be added for leakages, which depends on the quality of the pipe joints, as to which any economy in fitting up is a very questionable gain. For a leak leaks twenty-four hours per day and carries off a proportionately large amount of air.

Air mains are frequently of great length—from 1 to 3 miles are common lengths. There must necessarily be some loss by leakage and friction in the mains in such long lengths, and it follows that great care is requisite in laying them. Every pipe should be tested. Settlement of ground is a fruitful cause of broken joints or pipes. A good joint should be flexible and not easily broken by expansion or contraction. due either to temperature or settlement.

If these points are satisfactorily dealt with the loss by leakage should not exceed 1 per cent. per mile and the loss of pressure by friction 1½ per cent. per mile. Such results have been frequently attained, and the engineer should be satisfied with no less.

The diameter of the mains and distributing pipes is important and depends on two factors, the quantity of air passing and the distance from the compressor.

The receiver is in reality part of the air main and in most cases may be dispensed with, the main itself being of ample capacity.

Where the compressing engines are of the wet type a good deal of water is carried over with the air into the mains and should be trapped out at a point not far from the engines. With the dry compressor there is also some amount of condensation which should be drained from the main, as dry air is of advantage in the motors, especially if the air is not reheated. Moist air sometimes produces a good deal of ice at the exhaust.

The diameters of the mains depend upon the maximum quantity of air to be delivered, taking into consideration also the reduction in volume it sustains by cooling after passing the delivery valves. This varies between the isothermal and adiabatic lines of the air diagram and can readily be ascertained by computing the area of the diagram outside the isother-

mal line as compared with the area of the whole diagram.

It may be assumed that the air will have cooled to atmospheric temperature in about fifteen minutes, more or less, according to its delivery temperature, therefore the point along the main at which it may be reduced to its minimum diameter can easily be found.

Expansion joints should be avoided as far as possible; their place can be taken by bends, or, better still, by a flexible form of packing rings or jointing.

The velocity of the air in the mains and branches should not exceed forty feet per second.

Sluice valves are the best to use for all purposes on air mains.

The compressor is the most important item of the installation. There are wet and dry compressors. The former uses an internal jet of water to cool the cylinder in conjunction with a water jacket, and the latter a water jacket only.

Where a jet is used it should be forced in by a pump during the latter part of the compression stroke, not during the suction stroke, or it will be quite ineffective. Its value in cooling is doubtful, while its destructive action on the cylinder and piston admits of no doubt whatever. By all means use a dry compressor and take the inlet air direct from outside the engine house, that is, as cold as possible. This can be done by using a wood or sheet iron air trunk to the inlet valves.

It must be remembered that every degree gained in low temperature at the inlet means several degrees gained at the delivery, and that the engine-room air is usually about 20 degrees higher than outside.

Another important point is provision for utilizing the air in the clearances. The most simple and advantageous method of doing this is by the bye-pass method; ports or grooves are formed in the cylinder at each end a little longer than the thickness of the piston, so that at the end of the stroke these ports pass the air compressed in the clearances to the other side of the piston, where it adds to the initial pressure of the next compression stroke.

The inlet valve should have a positive movement, so as not to require suction to open it or pressure to close it, as both these cause loss of effective stroke and reduce the capacity of the cylinder.

A positive movement for the delivery valves is not so easy to design, as these valves should open at the moment the pressure in the cylinder reaches that in the mains, whatever it may be. This may be at any point in the stroke, so that it is customary to use spring-loaded valves, lightly sprung and of special design. If too heavy, the diagram will show the delivery line at top to be several pounds above the receiver or main pressure. This excess pressure is not all loss because the air expands to the pressure in the mains, but it increases the temperature which it is important to keep down.

Lubrication and its effectiveness depend upon the temperature, which in badly-designed engines often reaches 300 degrees to 350 degrees, at which point oil scorches and produces dry, burnt surfaces and corrosion. Gas engine oil should be used. But if proper attention has been given to the foregoing points the temperature at 60 lbs. should not exceed 180 degrees.

Good pistons, well fitted to the cylinder, are of more importance than in a steam cylinder; the absence of steam and its moisture causes dryer surfaces, and much leakage may occur which is difficult to locate in the diagram, as it merely causes the compression line to approach the isothermal, giving a false impression of high efficiency.

But the chief loss in every compressor is that due to heating during compression. the air, after passing the delivery valves, cools to atmospheric temperature and loses in bulk proportionately, the loss varying, according to the pressure and other points previously alluded to, from 25 to 60 per cent. and even more.

It is in this direction that the future improvement of air compressors must be aimed.

The latest designs are of the compound or stage-compression type, in which the compound principle of the steam engine is reversed, the air is compressed in two or more stages, passing through cooling coils or chambers between the stages. In this way the temperature can be kept down, but the increase of economy is not in proportion; the mechanical efficiency of the engine is reduced, piston and other leakages and losses are duplicated, and thus the chief actual gain is in the lower temperature and better lubrication.

Stage compression diagrams do not

show these losses and to this extent are misleading. The gain by stage compression is chiefly in working at a lower temperature than in the single compressor.

It is evident that the stage compressor does not cool the air while under compression in the cylinder, but in external coolers after it has passed the delivery valves, whereas the cooling ought to be done in the cylinder during compression.

A new type of compressor has lately been installed at the Murton Colliery of the South Hetton Coal Company. In this compressor the air is cooled before delivery and very high results have been obtained. With air cooling alone, that is, without water-jacket or spray, the air is delivered at 60 lbs. at a temperature of 160 deg., and with water sprayed over the tubes the temperature can be reduced to 110 deg.

With an engine of this type stage-compression is not required, except for pressures of 100 lbs. and over.

We have shown that the efficiency of a compressed air plant depends upon a number of small economies and attention to details, which, in fact, make all the difference between an efficient and a wasteful result.

There is another source of economy which has not yet made much progress, but presents a very promising future, that is, reheating the air before using it in the motors. At first sight one would say that what is thus gained must be lost in cost of coal or other heating medium, but this is by no means the case.

In practice, a very small quantity of coal will heat the air in a tubular heater to 250 deg. or 300 deg. (it is not desirable to heat it beyond 300 deg.), and expand the air to more than double the original quantity and thus similarly augment the useful effect in the motors, besides which the exhaust is discharged at a temperature above the atmosphere, and freezing thus avoided. Actual tests of reheating in this way have shown that the efficiency of the entire plant can be brought up to 100 per cent., that is to say, as much work can be given out at the motors as is supplied to the compressor in steam energy.

Without reheating, a plant should show an efficiency of at least 50 to 55 per cent.

There are several ways of reheating which are more or less applicable to all cases. A furnace and coil or surface heater is the simplest, but is inapplicable in fiery mines. Where steam boilers exist underground steam pipes can be employed to heat the air, the temperature obtained being of course not more than about 180 deg. A furnace or oil burner has been used inside the air main, the products of combustion passing with the air to the motors. Some simple adaptation of this plan as an appliance attachable to any motor seems to be the best form capable of universal application.

This subject is well worth the attention of engineers. To be able to fire a range of boilers with dust or coke gases, producing steam on the most economical scale, and then to be able to obtain the full mechanical energy of this steam in air motors underground a mile or two away from the boilers, without loss, is a most attractive outlook for the mine-engineer and owner, and we do not see how it can be improved upon or rivaled by any other form of power transmission.

Reheating enables the motors to run with a much higher grade of expansion than with cold air. With the latter we get in the motor a reversal of the effects of heating described as going on in the compressing cylinder, that is to say, we get adiabatic cooling instead of isothermal, the effect being to reduce the pressure and volume of the air more rapidly than is due to its expansion only. Keeping the motor cylinder hot will remedy this and induce isothermal expansion.

The next improvement required in air motors is, therefore, means of heating the air before entering the cylinder, and this should be done in such a way as can safely be used in fiery mines.—T. W. Barber, in *The Coal and Iron Trade Review.*

## Adiabatic Expansion and Compression of Gases.

In this article we will furnish the means of finding the temperature of adiabatic compression and expansion of gases, and this without the use of anything more than the mere rudiments of ordinary arithmetic. For this purpose the table given below has been computed from the formula:

$$\text{Log.}\ \frac{P^1}{P} \times \frac{2}{7} = \text{index logarithmic ratio,}$$

where $P^1$ is the greater pressure. Ow-

ing to a slight difference in the specific heat of air at different temperatures and pressures the formula does not at all times give results that are perfectly correct, but the limit of error is well within the requirement of good engineering practice:

| Gauge Pressure. | Atmospheres. | Logarithmic Ratio. | Gauge Pressure. | Atmospheres. | Logarithmic Ratio. |
|---|---|---|---|---|---|
| 10 | 1.69 | 1.16 | 76 | 6.17 | 1.68 |
| 11 | 1.74 | 1.17 | 77 | 6.24 | 1.68 |
| 12 | 1.81 | 1.18 | 78 | 6.31 | 1.69 |
| 13 | 1.88 | 1.20 | 79 | 6.38 | 1.69 |
| 14 | 1.95 | 1.21 | 80 | 6.44 | 1.70 |
| 15 | 2.02 | 1.22 | 81 | 6.51 | 1.70 |
| 16 | 2.08 | 1.23 | 82 | 6.58 | 1.71 |
| 17 | 2.15 | 1.24 | 83 | 6.64 | 1.72 |
| 18 | 2.22 | 1.25 | 84 | 6.71 | 1.72 |
| 19 | 2.29 | 1.27 | 85 | 6.78 | 1.72 |
| 20 | 2.35 | 1.28 | 86 | 6.85 | 1.73 |
| 21 | 2.41 | 1.29 | 87 | 6.92 | 1.73 |
| 22 | 2.49 | 1.30 | 88 | 6.98 | 1.74 |
| 23 | 2.56 | 1.31 | 89 | 7.05 | 1.74 |
| 24 | 2.63 | 1.32 | 90 | 7.12 | 1.75 |
| 25 | 2.70 | 1.33 | 91 | 7.19 | 1.75 |
| 26 | 2.76 | 1.34 | 92 | 7.26 | 1.76 |
| 27 | 2.83 | 1.35 | 93 | 7.33 | 1.76 |
| 28 | 2.90 | 1.35 | 94 | 7.39 | 1.77 |
| 29 | 2.97 | 1.36 | 95 | 7.46 | 1.77 |
| 30 | 3.04 | 1.37 | 96 | 7.53 | 1.78 |
| 31 | 3.10 | 1.38 | 97 | 7.60 | 1.78 |
| 32 | 3.17 | 1.39 | 98 | 7.66 | 1.79 |
| 33 | 3.24 | 1.40 | 99 | 7.73 | 1.79 |
| 34 | 3.31 | 1.41 | 100 | 7.80 | 1.80 |
| 35 | 3.38 | 1.42 | 105 | 8.14 | 1.82 |
| 36 | 3.44 | 1.42 | 110 | 8.48 | 1.84 |
| 37 | 3.51 | 1.43 | 115 | 8.82 | 1.86 |
| 38 | 3.58 | 1.44 | 120 | 9.16 | 1.88 |
| 39 | 3.65 | 1.45 | 125 | 9.50 | 1.90 |
| 40 | 3.72 | 1.45 | 130 | 9.84 | 1.92 |
| 41 | 3.78 | 1.46 | 135 | 10.18 | 1.94 |
| 42 | 3.85 | 1.47 | 140 | 10.52 | 1.97 |
| 43 | 3.92 | 1.47 | 145 | 10.86 | 1.98 |
| 44 | 3.99 | 1.48 | 150 | 11.20 | 1.99 |
| 45 | 4.06 | 1.49 | 155 | 11.54 | 2.01 |
| 46 | 4.12 | 1.50 | 160 | 11.88 | 2.02 |
| 47 | 4.19 | 1.51 | 165 | 12.22 | 2.04 |
| 48 | 4.26 | 1.51 | 170 | 12.56 | 2.06 |
| 49 | 4.33 | 1.52 | 175 | 12.90 | 2.08 |
| 50 | 4.40 | 1.53 | 180 | 13.24 | 2.09 |
| 51 | 4.47 | 1.53 | 185 | 13.58 | 2.11 |
| 52 | 4.54 | 1.54 | 190 | 13.92 | 2.13 |
| 53 | 4.61 | 1.54 | 195 | 14.26 | 2.14 |
| 54 | 4.68 | 1.55 | 200 | 14.60 | 2.15 |

| Gauge Pressure. | Atmospheres. | Logarithmic Ratio. | Gauge Pressure. | Atmospheres. | Logarithmic Ratio. |
|---|---|---|---|---|---|
| 55 | 4.74 | 1.56 | 205 | 14.94 | 2.17 |
| 56 | 4.82 | 1.57 | 210 | 15.28 | 2.18 |
| 57 | 4.88 | 1.57 | 215 | 15.62 | 2.20 |
| 58 | 4.95 | 1.58 | 220 | 15.96 | 2.21 |
| 59 | 5.02 | 1.58 | 225 | 16.30 | 2.22 |
| 60 | 5.08 | 1.59 | 230 | 16.64 | 2.23 |
| 61 | 5.15 | 1.60 | 235 | 16.98 | 2.25 |
| 62 | 5.21 | 1.60 | 240 | 17.32 | 2.26 |
| 63 | 5.28 | 1.61 | 245 | 17.66 | 2.27 |
| 64 | 5.35 | 1.61 | 250 | 18.00 | 2.28 |
| 65 | 5.42 | 1.62 | 255 | 18.34 | 2.29 |
| 66 | 5.49 | 1.63 | 260 | 18.68 | 2.31 |
| 67 | 5.55 | 1.63 | 265 | 19.02 | 2.32 |
| 68 | 5.62 | 1.64 | 270 | 19.36 | 2.33 |
| 69 | 5.69 | 1.64 | 275 | 19.70 | 2.34 |
| 70 | 5.76 | 1.65 | 280 | 20.04 | 2.35 |
| 71 | 5.83 | 1.65 | 285 | 20.38 | 2.37 |
| 72 | 5.90 | 1.66 | 290 | 20.72 | 2.38 |
| 73 | 5.96 | 1.66 | 295 | 21.06 | 2.39 |
| 74 | 6.03 | 1.67 | 300 | 21.40 | 2.40 |
| 75 | 6.10 | 1.67 | 305 | 21.74 | 2.41 |

Air at 60° F. is compressed adiabatically to 100 pounds gauge pressure, what will be its temperature? Looking in column one under gauge pressure we find the number 100, and opposite it in column three we find the logarithmic ratio to be 1.80; then multiplying the absolute temperature 60 plus 460.66 or 520.66 by 1.80 we get 937; subtracting 460 we have the answer, 477° F.

Air at 75 pounds pressure and 60° F. expanded to the atmospheric pressure, what will be its temperature? Looking in column one we find the number 75 and opposite that in column three we find the ratio to be 1.67. In this case we divide the absolute temperature 520.66 by 1.67, which gives us 311, which subtracted from 460 gives the answer—149° F.

A gas engine with a compression chamber of one-third and a stroke of two-thirds, what will be the temperature and pressure of the compression? In this case the compression isothermal will be three atmospheres absolute. Looking in column two under atmospheres we find the number 3.04, which is near enough for our purpose, and the ratio that corresponds is 1.37; multiplying by the absolute isothermal pressure, 43.1 pounds, we

get 59 pounds absolute or 44.3 gauge pressure. The explosive mixture before compression consisted of two-thirds air and gas at 60° F. and one-third the spent gases of the previous explosion of say 1000° F., giving to the charge the temperature of 373° F. or 833 absolute; multiplying by the same ratio as before gives us 1141 absolute or 681° F.

In the same cylinder, the temperature being 2681° F. and the gauge pressure 150 pounds per square inch, what will be the temperature and pressure at end of the working stroke? The expansion being from one to three we use the same ratio, 1.37, the exhaust pressure isothermally would be 50 pounds per square inch; dividing the absolute pressure, 64.7 by 1.37 we get 47.2 absolute or 32.5 gauge. The temperature, 2681° F. or 3141 absolute, divided by 1.37 gives 2292 absolute or 1832° F. at the pressure of the exhaust; when expanded to the atmosphere the heat of the spent gases would be 1083° F. —H. D. Dibble, in *Mining and Scientific Press.*

## A New Idea for an Air Compressor.

Our attention has been called to a patent dated March 4, for an air compressor granted to Mr. David O'Connell, of Brooklyn, which embodies features of sufficient novelty to warrant a description of it in our pages.

In principle the machine consists of two reservoirs, an automatic see-saw float which controls the main valve and an ordinary steam pump with the few pipes necessary to connect the tanks, pump and valves.

The principle of the device is the alternate flooding of the tanks with water by means of the pump and the compression of the air contained in the tank above the water. Two tanks are provided, so that the operation is continuous, the air being compressed in one tank while the water is being withdrawn from the other.

The tanks may be made of any size and heavy enough to stand any pressure. The pump may be either steam or electric, motor driven or one of the many belt driven types. The see-saw float is shifted when the water in either of the tanks reaches an overflow pipe and floods either one of the chambers in which the floats work. When this see-saw tips it swings a valve, which starts the water in the other tanks and allows the first tank to empty.

In the discharge pipe connected to the top of the tanks are suitable check valves which open when the air pressure has reached the proper point, thus allowing the compressed air to pass into the mains connected to whatever apparatus the compressor is operating. It will be understood that the action of the pump is continuous, and owing to the use of water there are no pistons, piston rods or working parts in the tanks, and the friction incident to these is eliminated.

There is also an absence of lubricating oils in the tank, so that the air produced is always clean. Also, as the air is in contact with the water at all times, it is claimed that the compression is practically isothermal. It is also claimed that there is no limit to the pressure which can be produced, because it is possible to use a high pressure pump to fill the tanks. We have made no investigation as to the operation of the machine, and therefore cannot say anything as to its economy, but in a general way there would seem to be cases where a machine of this sort could be employed to good advantage. For instance, where there is abundant water power under a fair head when the pump could be done away with entirely and the water used directly, thus making the device the converse of a displacement pump.

## Electric and Compressed Air Locomotives.

In America the electric or compressed air locomotive is in frequent use in shops, foundries and manufactories, where in England we should generally employ the ordinary steam engine. More especially is this so on narrow-gauge lines. The whole matter, of course, resolves itself into a question of economy and convenience. We may rest assured that our cousins across the sea would not have adopted the electric or air-driven locomotive in preference to the steam engine simply because it pleased them to do so. We may be very certain that they thought they would save money, either directly or indirectly, by doing so. On the same grounds we may equally say that the steam locomotive is the

leading favorite as present in this country. In view of this descrepancy of opinion, however, we think that it may be of interest to our readers if we illustrate and briefly describe some of the types of narrow-gauge electric and compressed air locomotives in use in America, so that they may be able to judge whether or not it would be wise to adopt in this country means of haulage other than steam, all considerations being taken into account.

We will describe four locomotives, the first of which is a storage battery electric locomotive; the second and third are for overhead collection, rail return; while the fourth is a compressed air locomotive. These are, all of them, types in every-day use, and devoted to widely differing objects.

Taking them in the order mentioned above, the first an electric locomotive made by the C. W. Hunt Company. It is constructed to easily run around curves of 12 feet radius, and every wheel of its two bogies is a driving wheel. It obtains its motive power from a storage battery contained in the covered box between the motors. The battery plates are made specially heavy, since it is claimed that, besides insuring durability and efficiency, the great weight adds to the adhesion—and hence the hauling power—of the locomotive. Of course, this great weight precludes the use of such locomotives for long and steep gradients or for high speeds; but, on the other hand, there is the large draw-bar pull, and the speeds attained are said to be ample for any ordinary work. At all events, the advocates of this type of locomotive say that in manufacturing establishments where the ground is level, or where at most short gradients of from 5 to 6 per cent. are met with, it is by far the most convenient, economical and efficient means of taking goods from one place to another. The weight of the locomotive complete is five tons, and the gauge on which it runs 21½ inches. It is 13 feet long over all, and about four feet wide. To the top of the motors it measures some 5 feet, 6 inches, and if a canopy is fitted it is 8 feet, 4 inches to the top of this. Generally speaking, it can haul a load up to its full capacity at a rate of some four miles per hour, while one charge is said to be sufficient for a working day of 10 hours. As to its actual hauling power, it is stated that it can deal with a load of 50 tons on the level. The motors are of the iron-clad type, and the gearing is enclosed in an oil-tight case. Of course, against all the possible advantage of using a locomotive of this type must be placed the fact that storage batteries in unskilled hands are liable to be a great source of trouble. On the other hand, there are no overhead wires to get in the way, and no bonding of rails to keep in order.

The second and third are two types of locomotives which, contrary to the foregoing, take their current from an overhead wire and return it through the rails. The first engine was constructed at the Baldwin Locomotive Works, and is known as the Baldwin-Westinghouse electric locomotive. Its gauge is 2 feet 6 inches, and it is provided with two motors which work at 500 volts. The diameter of the driving wheels is 30 inches, and the wheel base is 4 feet. Its total length is 10 feet, its width 4 feet 11 inches, and its height 9 feet 4 inches, and its weight nearly 8½ tons. It is adapted, therefore, to considerably heavier work than the locomotive just described. The third is a four-wheel mining locomotive made by the Jeffrey Manufacturing Company. Its total weight is four tons, and it is practically entirely iron-clad. Of course, it would be impossible to use this type of locomotive with its overhead collection in coal mines, which are dangerous owing to fire-damp; but in the United States one of the principal applications of these narrow-gauge electric locomotives is in connection with collieries, and the duty required of them is the taking of loaded trucks from the pit mouth or tunnel, as the case may be, to the various sorting and washing buildings or to the standard gauge railway wagons. They are also, so we understand, much used in quarries, sand-pits, blast furnaces, sugar, coffee and other plantations; in fact, in any place where there is a continual transport of raw material, such as ore, charcoal, coke, vegetable produce or earth. It is said that the saving by their employment is considerable, and that in places where there are large fire risks, and where the use of the steam locomotive is impossible, their adoption is almost imperative.

As already intimated, however, in a dangerous coal mine or—to take another instance—in a powder mill, an electric

motor may be a source of disastrous explosions. For such places as these comes the opportunity of compressed air locomotives. Indeed, we are informed that they are competing largely in other directions less dangerous than these with the electric locomotive, being used not only in mines, but for coal and mineral work, and also for hauling trains through tunnels and city streets, and for transporting material, lumber, paper, etc., to cotton mills and warehouses. The fourth is a type of such locomotives as are manufactured by the H. K. Porter Co., and employed at the Iowa powder mills. The weight of this engine is 15,000 lbs., and its cylinders are 7 inches by 14 inches, the gauge being 42 inches. The air for locomotives of this class is stored in one or more steel tanks—in the present instance there is but one tank—and the cubic capacity is, of course, regulated by the work required, and by the length and nature of the journeys to be made. The air tanks occupy a similar position to that taken up by the boiler in a steam locomotive. The factor of safety is high. In one case, for example, if the ordinary air pressure to be withstood is 600 lbs., an hydraulic test pressure of 1,000 lbs. is applied. If auxiliary or letting-down tanks are used, the pipes joining the two tanks are of copper. The troubles due to fall in temperature owing to the expansion of the air would appear to have been overcome—perhaps by carefully drying the air before it is compressed. At any rate, the advocates of compressed air claim that locomotives worked by this medium run longer, with less repairs and breakage, and with less leakage than with steam, on account of better lubrication and absence of heat. Further, they claim for the air-driven machine, which is only worked intermittently, that it is more economical than the electric motor used under the same circumstances.—*The Engineer.*

## Notes.

Messrs. C. E. Walker and C. Booth, of the Chicago Pneumatic Tool Company, have departed for Europe in the interest of the company.

The Philadelphia Pneumatic Tool Company has appointed Messrs. Berger, Carter & Company, No. 330 Market street, San Francisco, Cal., their representatives on the Pacific coast.

The capacity of air for carrying moisture depends upon its volume and temperature and not upon its pressure. Air compressed to 1,000 pounds pressure will contain but little more moisture than the same air at atmospheric pressure.

The death of Mr. Camille Ferroux, the inventor of the rock-drill bearing his name, has been announced in one of the London papers. Mr. Ferroux was a distinguished engineer who took an active part in drilling the Mont-Cenis, St. Gothard and Arlberg tunnels.

The Jeffrey Mfg. Company's plant at Columbus, Ohio, is not a very large one, but it is worthy of especial note, considering how cleverly and economically it is operated. The air compressor furnishes power for a number of pneumatic tools and hoists throughout the works.

"The More Drills the Merrier," seems to be the motto of the Cosmopolitan Proprietary Cyanide Plant in Kalgoorlie. We note from latest reports that their two six-drill capacity air compressors are being supplemented by a new twenty-drill compressor, which speaks not only well for the prosperous atmosphere of West Australia, but also for their present good business.

The McKiernan Drill Company, of 120 Liberty street, works at Dover, N. J., have just secured an order from the New Jersey Zinc Company, of New York, for two Cross compound condensing Corliss air compressors, with a capacity of 6,534 cubic feet of free air per minute each, involving a transaction of $50,000. These compressors are to be used in their zinc mines at Franklin Junction, N. J.

Mr. Jean F. Webb has sold one-half of his pneumatic cyanide patent to the Colorado Iron Works Company. A new company with $500,000 capital has been formed to build mills and exploit the process. Mr. J. W. Nesmith is president, Mr. J. H. Morcom, vice-president, and Jean F. Webb, Jr., secretary of the new

organization. The headquarters of the new company is in the Albany Hotel Building, Denver, Colorado.

Mining in the district of Cornwall, England, does not seem to be booming at the present time, and we notice but one mine, situated at Wheal Kitty, which has seemed to feel especially encouraged with conditions prevailing. Here the conditions are almost unprecedented and the company are congratulating themselves that prosperity has come at a time when they are so well provided and equipped with air compressing machinery and rock drills.

It is said that an enterprising clergyman of St. Louis, the Rev. Chas Stelzle, is giving a series of sermons on parables founded on "The Machine Shop," "Life in the Foundry," etc. Presumably these talks are given to appeal directly to machinists and those people who are interested in that line of thought, and the question arises in our minds what connection, for example, a compressed air hoist or a pneumatic tool could have to do with the salvation of the soul.

In the building of the tunnel beneath the River Thames, London, for the Baker-Street and Waterloo Electric Railway, compressed air was used and this particular power was made absolutely necessary by the conditions arising during the operation. At first the tunnel was built wholly in London clay, but after a bit a bed of clean gravel and sand was encountered, laid in an abrupt depression of the surface, and as you can readily see, this freely water-bearing bed necessitated very delicate handling, and was peculiarly adapted to compressed air methods.

Mr. J. Geo. Leyner, Denver, Colorado, the well-known manufacturer of air compressors and rock drills, has just issued a descriptive catalogue of his make of air compressors. It is one of the most comprehensive and conservative treatises on air compressors and the use of compressed air that we have ever seen issued as a trade publication. Every mining man should possess a copy (whether he has ample air compressor machinery or not) on account of the valuable information it contains.

The American Schools of Correspondence, of Boston, Mass., calls attention to the facilities for home study that it offers industrious ana ambitions young men. In its "Handbook," a pamphlet of 100 pages, the advantages of the school are fully set forth and the various courses of study are described. The school offers courses in electrical, mechanical, stationary, marine, locomotive and textile engineering, also in heating, ventilating and plumbing. The school also offers special courses in arithmetic, elementary and advanced algebra, geometry, mechanical drawing, elementary chemistry and metallurgy, chemistry and dyeing, heating and ventilation, electric power and lighting, and other subjects.

Gold mining on the Rand at the present time has a certain fascinating sound whether we are waiting for the "Open Door," and anticipating the end of the Boer war, or merely idle listeners, weaving romances a la Cecil Rhodes. Mr. John Stuart, of the *London Post*, in speaking of this very subject, and talking in a general way of the work on the different mines out there, is inclined to think that the haulage which has been done for some time with electric engines, will have to give way entirely to compressed air, and that nearly all of the rough work on the mines is best accomplished by rock-drills operated by this motive power.

The firm of H. K. Porter & Co. began business in 1866, under the name of Smith & Porter, with a shop of one rented room in Twenty-eighth street, Pittsburg, Pa. There were a man and a boy, besides the "firm." They grew fast, however, and soon built a shop of their own. On March 4, 1867, the first locomotive was contracted for, and shipped on Thanksgiving Day. It was a four-wheel saddle-tank engine, 42-inch gauge. In February, 1871, the shop was burned, and on rebuilding the firm name was changed to Porter, Bell & Co., which lasted until the death of Mr. Arthur W. Bell, in 1878, when the present firm name was adopted. They

have built everything from 18 to 72-inch gauge and from 4 to 45 tons, and for all parts of the world.

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What power? Why, compressed air. On the Rand, South Africa, before the Boer war, *Mining and Scientific Press* presented a plan in connection with the power to be used for one of the especially deep mines out there, which comprised the installation of a hoist at the surface that would hoist from a depth of 2,700 feet; at that depth another hoist of equal capacity, and at the 5,400-foot level a third, to hoist from the 8,000-foot. This matter is still open and involves among other things a question of what kind of power. To this it would appear that electricity can be relied upon in such a case; so also can compressed air, and the subject presents a favorable field for thought, to say nothing of American enterprise and skill, with the customary attendant profit.

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The Pneumatic Signal Company, of Rochester, N. Y., also owns the controlling interest in the British Pneumatic Railway Signal Company, of England, which has installed the first system of automatic block signals as well as the first pneumatic interlocking system in Great Britain. This company has received further the orders for eight large low-pressure pneumatic interlocking plants and 31 block stations in England. It is also forming continental companies for the handling of its various appliances. Mr. Charles Hansel has been elected assistant to the president of the company, with offices in New York and London, England. Mr. Hansel was formerly vice-president and general manager of the National Switch and Signal Company.

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The Philadelphia Pneumatic Tool Company has just issued a new catalogue, in which they describe the several types of pneumatic hammers, chippers, drills and other tools which they manufacture. We commend this pamphlet to our readers on account of the very practical information which it gives in tabular form.

In addition to illustrations and brief descriptons of the different types of tools which they manufacture, a number of half-tones are given showing the tools in actual operation. These are new and give very satisfactory evidence of the utility of pneumatic tools in general, and especially of the Keller tools, which are manufactured by the Philadelphia Pneumatic Tool Company, whose main office is at Philadelphia, Pa. The catalogue is handsomely gotten up, well printed on heavy paper and will prove an attractive addition to any collection of catalogues.

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On Wednesday last the Benedict & Burnham Mfg. Company, of Waterbury, Conn., purchased through James D. Williams, of New York, and Hugh L. Thompson, engineer, of Waterbury, Conn., the tube-making machinery, licenses, shop right and patents owned by the Mannesmann Cycle Tube Works of Zylonite, town of Adams, Mass. The company was organized sometime in 1896 by the Mannesmann Brothers—Max, Reinhardt and Alfred—the sons of the inventor of the Mannesmann process and machines. Through some misfortune or mismanagement the project failed and the Mannesmanns gave up in August, 1898, without having successfully started the works. The plant was then leased to responsible people, who ran a part of it from November, 1898, to some time in May, 1899, in which time they produced about 450,000 lineal feet of merchantable bicycle tubing. Since that time the works have been idle, and the property was finally sold by order of the District Court of the United States for the Southern District of New York. The tube machinery will be removed and the property used for manufacturing purposes.

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We all know the value of compressed air machine tools for railway work; but the value of air jacks for cars and locomotives is not so generally known. It formerly required about four hours for eight men with screw jacks to take a 10-wheel engine weighing 132,000 lbs. off its drivers, at a cost of $5.14, and about one-half that time for four men to do the same work with hydraulic jacks, but using four pneumatic jacks, it is now regularly done by four men in one hour at a cost of 66 cents.

A pneumatic ram was recently made at a cost of $168.55 for breaking stay-bolts to remove worn-out fire-boxes, which earns very large interest on the investment. It formerly cost $45.60 to cut out the crown-bolts and stay-bolts of a 10-

wheel locomotive with 9-foot fire-box, using three men, but with the pneumatic ram it is done by two men for $15.20, thereby saving $30.40 on each fire-box. If only one fire-box was removed each year this tool would earn 18 per cent. on the investment, but as this shop applies 30 new fire-boxes a year the saving amounts to $912, or 541 per cent. per annum on the amount invested.

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At the Ronchamp Colliers, France, described with more detail in *The Colliery Guardian,* the great shaft has a depth of 1,010 metres, with a power plant comprising two air compressors capable of furnishing 10 cubic meters of air at 5 kilogs. pressure per minute. Each of them consists of a compound engine and a compressor, the high pressure cylinder of the former having a diameter of 500 mm., low pressure cylinder 850 mm., and stroke 1,100 mm. The steam is distributed by means of slide-valves, the cut-off being a semi-cylindrical slide-valve which can be adjusted by the driver. Each steam cylinder works a corresponding compressor cylinder, in the same horizontal axis and having the following dimensions: Diameter, 560 mm.; stroke, 1,100 mm. The bottoms of these cylinders are fitted with small intake and delivery valves, and the compressed air is cooled by an injected water spray, supplied by pumps actuated by eccentrics keyed on the shaft of the fly-wheel. The normal speed of the engine is 36 revolutions per minute to furnish the amount of air specified above; but this speed can be easily increased to 45 revolutions. The steam pressure in the small cylinder is 8 kilogs, per square centimetre.

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Something new—compressed air as a lifting agent. The old pioneer iron furnaces used two methods of elevating the stock from the yard to the furnace top. At first they tried the water balance and later awakened to the fact that the air balance would answer their purpose better. This consisted of a cylinder *D,* about 36 inches in diameter and long enough to carry the platform to the furnace top. The piston *E* was hollow and filled with pig iron until its weight was slightly less than the combined weight of the two platforms and empty barrows. Starting with the platform in the position shown, air from the blowing engines was admitted on top of the piston. This air was at a pressure of about 2½ pounds per square inch, which was sufficient to force the piston downward and lift the platforms and their load. After the load was discharged and the barrows replaced on the platform, the air was exhausted from the cylinder, thus allowing the weight of the platform and empty barrows to return them to the bottom. This machine worked beautifully and never gave trouble of any kind, except in the coldest weather, when it was necessary to admit steam and heat up the cylinder from bottom to top in order to remove the frost that collected on the surface and prevented the free movement of the piston.

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The Yoch improved coal mining machine is described in a 20-page pamphlet published by the Belleville Pump and Skein Works of Belleville, Ill. This machine is of the pick type and uses compressed air. The company states that it has acquired all the patent rights for the United States and foreign countries for the manufacture and sale of the machine, and that it has executed all the Yoch Mining Company's improvements and manufacturing since 1882. The construction and appearance of the machine have been radically changed and the manufacturers now claim for it these merits: Excellence of material and workmanship; interchangeable parts; weigh enough to allow high pressure behind the piston, insuring a vigorous blow; a piston cushioned on air, doing away with metallic or leather buffers; packing easily accessible and an adjustable center, permitting the machine to be balanced for different lengths of picks. The manufacturers also state the machine will undercut 6 feet without too much jarring on the operator and that they will undertake to work the machine in any room or entry where any other machine can be worked. The Belleville Pump and Skein Works also manufacture the Smith double rotary air drill, mine fans, coal mine cars, chilled car wheels, screens, etc.

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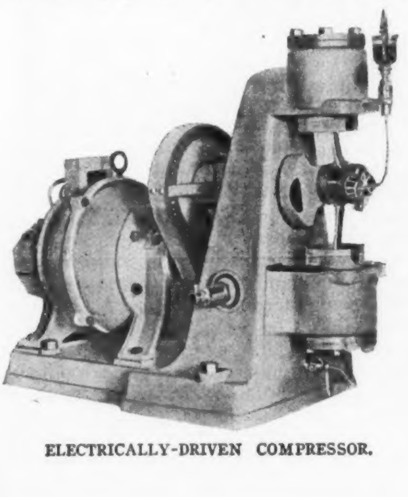
To think of Athens, Greece, carries us back hundreds of years to scenes which are of so historic an interest and to a city of so romantic an atmosphere, that it seems almost sacrilegious to find that it is a very up-to-date, wide-awake city after all, and that it "Can't help its past and just means

to catch up any how." We now hear that within easy walking distance of the Acropolis at Athens, and near by the Temple of Theseus, they have built one of the largest compressed air plants (of its kind) in the Levant. Compared with the seven large plants of Paris it will be noticed that with the exception of one of the Paris plants, the Athens plant exceeds by 3,000 H. P. the largest of these companies. We give you below the table of comparisons:

| | H. P. |
|---|---|
| Usines Municipales | 2,450 |
| Usines de la Cie. Edison | 5,600 |
| Usines de la Cie. du Secteur Clichy | 2,800 |
| Usines de la Société d'éclair et force par d'électricité | 5,300 |
| Usines de la Société des Halles Cen., I | 1,200 |
| Usines de la Société Secteur des Champs Elysées | 4,800 |
| Usines de la Cie. Parisienne d'air compr | 12,800 |
| Greek Electric Co.'s plant at New Phaleron | 8,620 |

Messrs. Reavell and Company, Limited, of Ipswich, have issued circulars describing their small compressors. The electrically-driven type is being supplied to electric lighting and power stations. It is of the patented duplex type, and has a capacity of 18 cubic feet of free air per minute. It is driven by a motor of the enclosed type, of 1½ to 2 H. P., depending on the delivery pressure. The frame of the compressor is designed so as to form an air reservoir, and is fitted with relief valve, drain cock and outlet connection screwed 1 in. gas. The base of the compressor is extended to carry the motor, which runs at about 1,200 revolutions per minute, and drives the compressor at 400 revolutions per minute through gear-wheels, the pinion being of raw hide, and the spur-wheel of cast-iron, machined from a solid blank. The gears are protected by a neat planished steel case. The motors are supplied to suit any desired voltage. The machine is designed for delivery pressure up to 30 pounds per square inch, and is usually worked at 15 to 20 pounds pressure.



ELECTRICALLY-DRIVEN COMPRESSOR.

Gas in Los Angeles, Cal., is generated and distributed by the aid of two air compressors and gas engines, which have lately been installed. When the need came for larger mains a six-inch feeder main, about three miles in length, was laid and a compressor and gas engine connected at the end leading from the Seventh street works. The compressor is duplex, 16 x 18, running at 100 revolutions per minute, and is belted to a three-cylinder, vertical, eighty-five horsepower gas engine running at 300 revolutions per minute. The gas at present is compressed to a pressure of thirteen pounds gauge, and a pressure of twenty or thirty pounds is contemplated when required. High pressure meters (No. 1 Equitable Meter Company's dry meters) and regulators (No. 1 Equitable Meter Company's) are used for consumers along the line, and at the end a 6 x 8 Equitable Meter Company's governor is in the line. It has not, however, been found necessary to use this governor as yet. The gas leaves the governor under the present initial pressure of thirteen pounds at the works—at the end of its passage of almost three miles—at from seven to nine inches water pressure, and no house regulators are used at this pressure. The compressor is operated on the peak loads only, and the house regulators operate equally well with normal or with high pressure.

Another and smaller compressor is being operated from the Aliso street works for supplying another district, and the feeder is a two-inch pipe over a distance of 7,000 feet. The initial pressure is thirteen pounds gauge, and the pres-

sure at the first consumer's meter, 7,000 feet distant, is thirty inches water pressure. No regulator whatever is used, and the service is satisfactory. The company is now completing a six-inch line to the city of Pasadena, eight miles distant, and will deliver the gas under pressure of probably fifty pounds to the square inch. These are valuable lessons to the fraternity, and open up a wide vista of profitable engineering for other companies.

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On the Wachusett Dam of the Metropolitan Water Works, at Clinton, Mass., all the power needed is furnished from a central power station, which comprises two air compressors, each having a cross-compound condensing Corliss engine with steam cylinders 18 and 34 inches in diameter, air cylinders 24 and 21 inches, and a stroke of 42 inches. The engines were made right and left so as to have the high pressure steam cylinders adjacent to each other, the two compressors being set parallel to each other on well-built rubble and cut stone foundations. At a normal speed of 75 revolutions per minute each has a capacity of 3,310 cubic feet of free air raised to a pressure of 80 to 90 pounds. The engines are controlled by the regular Corliss speed governor which operates on the cut-off mechanism of the steam valves, and also by an automatic air regulator which controls them through the same means. The engines are arranged so as to run either the high or low pressure steam cylinder independently of each other. This provision is made so that in case of necessity four-tenths of the capacity of the whole machine can be made of service with the high-pressure side if the other is injured.

The compressed air is discharged through a 10-inch pipe connection into a horizontal air receiver 6 feet in diameter and 20 feet long. There is a 10-inch outlet pipe from the receiver and the air is distributed from it through wrought-iron air mains, 8, 6 and 4 inches in diameter. Reheaters are used at a number of places on these mains. All the quarrying and hoisting is done by compressed air.

The plant operated last season by compressed air included 10 drills at the quarry and the dam site, 15 hoisting engines, 2 pumps located in the pit, a sand screening engine, blacksmiths' forges, the two cableways and a cubical box mortar mixer. At present about 16 drills, 26 hoisting engines and 10 pumps are ready for use. The air is piped across both ends of the pit and numerous valved branches are inserted in the lines so that connections can be readily made with the hoisting engines and pumps.

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An interesting test of safety appliances on elevators was given recently by the inventor of the Ellithorpe Safety Air Cushion in Lit Brothers' department store at Philadelphia. The test proved in every way successful, and clearly demonstrated that riding in an elevator car can be made as safe and secure as walking on solid ground.

Lit Brothers have safeguarded their fourteen elevators with the new safety cushion, and it was to make a practical test of the appliance that the exhibition was given. Two cars, each weighing 3,000 pounds, were dropped from the top floor of the building to the bottom of the shaft, a height of 84 feet, without displacing, jarring or cracking a number of eggs or spilling the water in the several glasses which had been placed in the cars. This proved conclusively that a person within the car at the time of its drop would have hardly felt the fall, and beyond having his breath checked for an instant, would in no wise feel the effects of the sudden descent.

The test was made in the presence of the members of the firm and several mechanical engineers, the elevator constructors and Chief Building Inspector Hill. Mr. Ellithorpe, the inventor of the cushion, was in charge of the exhibition. Two cars in different sections of the store had been run to the top of the building. Here the cables were disconnected and the heavy cars were suspended by new manila ropes.

In the first car to be cut loose a number of eggs and several glasses of water had been placed. There were also two electric bulbs on top of the car. The spectators were gathered about on the first floor. Three men were on the top floor with a knife attached to a long stick of wood. Mr. Ellithorpe was below, and at a given signal announced that all was ready for the test. Another signal told

the men on top to cut the rope. A moment later a rumbling sound was heard. The car had been cut loose and was shooting swiftly through the shaft. The spectators held their breath.

The car shot past the first floor like a falling star. It struck the air cushion with a thud, and then slowly settled. The whole thing lasted three seconds. When the car was opened, everything within was just as it had been placed there. The water was not spilled. The eggs were not cracked, and the electric bulbs were intact. The test was as remarkable as it was successful.

A similar test was then made of the second car, with equal success. The eggs, which had been dropped 164 feet, were distributed as souvenirs to those present.—*National Engineer.*

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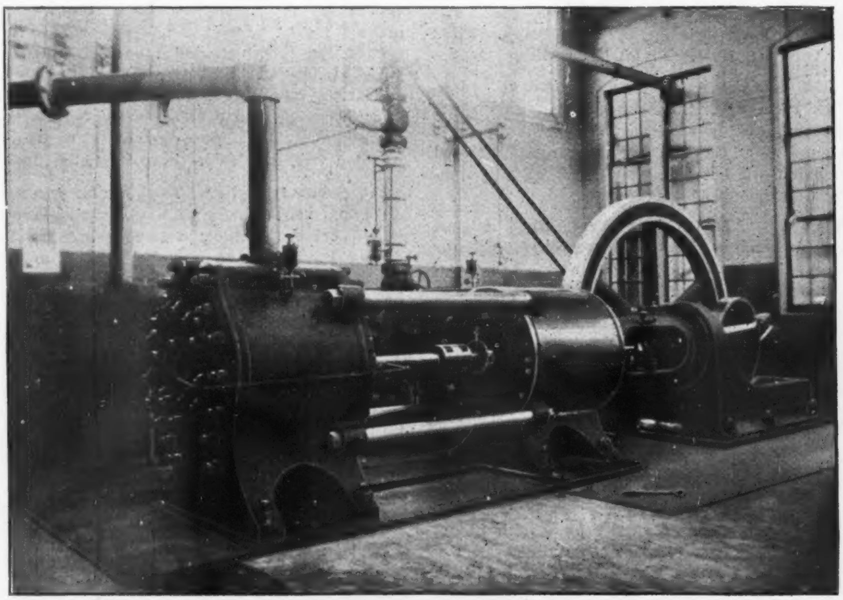
The accompanying illustration represents a Class D S. C. Air Compressor having duplex steam cylinders and two stage air cylinders, with inter-cooler, built by the Franklin Air Compressor Works, of the Chicago Pneumatic Tool Company, with offices in the Fisher block, Chicago, and 95 Liberty street, New York, installed in the Brooks plant of the American Locomotive Company at Dunkirk, N. Y. This compressor has steam cylinders 20 inches diameter by 24 inches stroke, low pressure air cylinder 27 inches diameter by 24 inches stroke, and high pressure air cylinder 16½ inches diameter by 24 inches stroke, representing a piston displacement of 1,580 cubic feet of free air per minute at a working speed of 100 revolutions. The illustration herewith presented is the first of this type of machine that has appeared in the press, it being especially noteworthy that the compressor demonstrated under test one of the most efficient performances ever attained by a compressor of this type and capacity. Similar compressors have recently been installed at the shops of the New York Central & Hudson River R. R. Co., at Depew, N. Y.; Lake Shore & Michigan Southern Ry. Co., at Collinwood, Ohio; New York, New Haven & Hart-



CLASS D. S. C. AIR COMPRESSOR, BUILT AT THE FRANKLIN AIR COMPRESSOR WORKS.

ford R. R. Co, at New Haven, Conn.; Delaware, Lackawanna & Western R. R. Co., at Kingsland, N. J.; Terre Haute & Indianapolis R. R. Co., at Terre Haute, Ind.; Norfolk & Western Ry. Co., at Roanoke, Va.; Erie Basin Dry Dock Co., Brooklyn, N. Y.; United States Navy Yard, Boston, Mass. (three machines). The manufacturers build this type of compressor in a number of sizes and also duplex and single types both steam driven and belt actuated.

## U. S. PATENTS GRANTED MAR. 1902

Specially prepared for COMPRESSED AIR.

694,403. ENGINE BRAKE. Edward Y. Moore, Cleveland, Ohio, assignor, by mesne assignments to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed April 19, 1901. Serial No. 56598.

An incased engine, an additional crank-disk therefor within the casing, said crank-disk removably engaging the crank-pin, and means for establishing braking frictional engagement between said disk and a non-rotative member.

694,525. AIR-BRAKE SYSTEM. August Brüggemann, Breslau, Germany, assignor to the Deutsche Waffen-und Munitions-fabriken, Karlsruhe in Baden, Germany, Filed August 7, 1900. Serial No. 26,-178.

A regulating valve for air-brake cylinders and mechanism operated by wind-pressure caused by the velocity of the train to load the same.

694,588. AIR-BLAST APPARATUS. James M. Tyler, Bay St. Louis, Miss. Filed February 18, 1901. Serial No. 47,795.

The combination with a frame, of a blower supported thereon, and having opposite outlets, slide-valves for the respective outlets, a rocking lever fulcrumed intermediate of its ends upon the frame and located between the valves, the latter being pivotally connected to the respective ends of the lever, a transverse rock-shaft, mounted between the valves, a cord or cable having its intermediate portion wrapped or coiled upon the rock shaft, and its ends connected to the respective ends of the lever, and guides located between the rock-shaft and the respective ends of the lever, the opposite portions of the cable being passed through the guides, and means for rocking the shaft.

694,611. AIR AND GAS MIXING AND SUPPLYING APPARATUS. George H. Burrows, Somerville, Mass. Filed Nov. 29, 1901. Serial No. 84,126.

An apparatus of the character specified comprising a mixing chamber having air and gas inlets and an outlet for the air and gas mixture, air and gas supply pipes connected with said inlets, a mixture-delivery pipe connected with said outlet, means controlled by the pressure of the mixture in the chamber and delivery-pipe for regulating the admission of air and gas to the mixing-chamber, and a telescopic air reservoir connected with said air-supply pipe and with a source of air supply.

694,638. VALVE FOR PNEUMATIC TIRES. William D. Hart, Bloomfield, N. J., assignor of one-half to Eugene M. Macdonald, Glenridge, N. J., Filed July 12, 1901. Serial No. 68,042.

694,714. PNEUMATIC DRILL. Thomas Barrow, Cleveland, O., assignor, by mesne assignments, to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed Oct. 29, 1900. Serial No. 34.730.

A pneumatic tool, the combination of a casing, an engine within the casing adapted to drive the tool, a cover-plate for the casing having valve-passages leading to the engine, a valve box formed on the outer side of said cover-plate, a hollow valve within said box having an opening from its interior for the admission, and a recess in its exterior, a passage through said cover-plate to said valve-box adapted to be in open communication with the operating fluid, an opening into the interior of the valve in communication with said entrance-opening in both of the operating positions of the valve.

694,885. AIR-COMPRESSOR. David O'Connell, Brooklyn, N. Y. Filed Sept. 13, 1901. Serial No. 75,334.

An air-compressor, the combination with two tanks, each having a valve connection with a pressure-receiver and the outer air respectively, one of said tanks containing water, a pump operatively connected with said tanks, a valve controlling the connections between the pump and said tanks and adapted to be turned to cause the water to be withdrawn by said pump from each of the tanks, in turn, and forced into the other, chambers communicating respectively with the upper end of each tank, a float in each chamber, a rock-shaft on which both of said floats are mounted and means actuating

said rock-shaft for alternately shifting the said valve as the water rises in each of said tanks successively.

694,978. AIR-LOCK. Daniel E. Moran, Mendham, N. J. Filed Nov. 26, 1901. Serial No. 83,694.

An air-lock provided with an opening for the passage of a bucket supported by a rope, a single door for said opening, and means to permit lateral movement of said bucket and rope whereby said door may be closed.

694,981. PNEUMATIC DRILL. John T. McGrath, Stratford, Canada. Filed Nov. 24, 1900. Serial No. 37,668.

In combination, the casing, the drill-spindle and driving means therefor, an air-pipe for supplying compressed air to said driving means, a cylinder carried by said casing, a piston working therein carrying a feed-spindle and a branch conduit from said air-pipe to said cylinder.

695,025. AIR-GUN. Walter R. Benjamin, St. Louis, Mo. Filed Sept. 11, 1900. Serial No. 29,674.

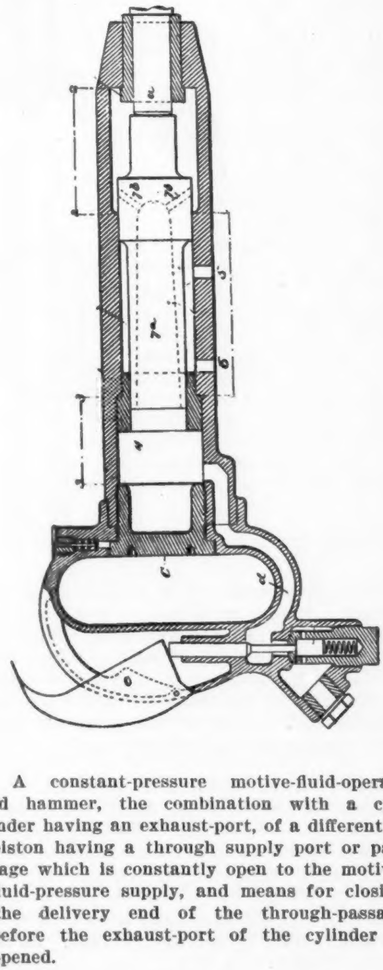
695,162. APPARATUS FOR CLEANING CARPETS. Augustus Lotz, San Francisco, Cal., assignor of one-half to Joseph Haas and Julius Kahn, San Francisco, Cal. Filed Dec. 4, 1900. Serial No. 38,602.

The combination in an apparatus for cleaning carpets or similar material, of a casing or frame, of a receiving-chamber in said casing or frame, an air passage-way extending through the casing, of means for supplying air to said passage-way and forcing the same against the carpet to eject the dirt and dust therefrom and deliver the same into the receiving-chamber, means for automatically removing the dust and air from the receiving-chamber, and a hood E surrounding the casing and communicating with the receiving-chamber.

695,199. AIR-PUMP. George W. Eddy, Waterbury, Conn., assignor to the Scovill Manufacturing Company, Waterbury, Conn., a Corporation of Connecticut. Filed June 1, 1899. Renewed Jan. 27, 1902. Serial No. 91,468.

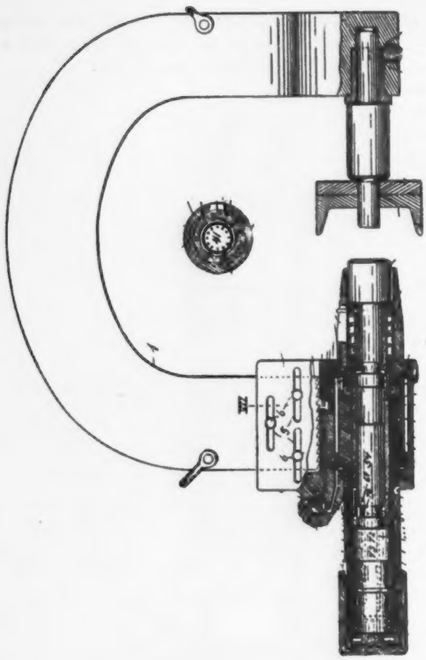
An air-pump, having a discharge-tube of rigid material and provided with a coupling for connecting the same with the inlet of an object to be inflated, and a yielding and detachable joint between the pump and the discharge-tube.

695,396. PNEUMATIC HAMMER. Charles H. Johnson, Chicago Heights, Ill. Filed June 10, 1901. Serial No. 63,957.



A constant-pressure motive-fluid-operated hammer, the combination with a cylinder having an exhaust-port, of a differential piston having a through supply port or passage which is constantly open to the motive-fluid-pressure supply, and means for closing the delivery end of the through-passage before the exhaust-port of the cylinder is opened.

695,415. PENUMATIC RIVETER. Charles B. Richards, Cleveland, Ohio, assignor, by direct and mesne assignments, to the Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio, and the Philadelphia Pneumatic Tool Company, Philadelphia, Pa., a Corporation of Pennsylvania. Filed December 19, 1900. Serial No. 40,347.



The combination of a suitably-supported cylinder having openings at both ends, a fluid-actuated hammer having a sliding fit in the end openings of said cylinder, and having a piston around it fitted to slide in the cylinder, and means for controlling admission and exhaust of the actuating fluid into and out of said cylinder.

695,437. AIR MIXER AND HEATER FOR GAS BURNERS FOR BLAST-FURNACE STOVES. Charles H. Björckner, Lorain, Ohio. Filed Feb. 9, 1900. Renewed Dec. 30, 1901. Serial No. 87,688.

695,492. AIR-PUMP. John Robertson, Cincinnati, Ohio. Filed Nov. 3, 1899. Serial No. 735,667.

An air pump, a cup-shaped cap to receive and shape a collapsible plunger and hold it in position while it is being inserted into the open end of the cylinder.

695,580. AIR-SHIP. Cassius M. Richmond, New York, N. Y. Filed Oct. 26, 1900. Serial No. 34,453.

695,632. COMPRESSED-AIR WATER-ELEVATOR. Greenlee D. Buchanan, Jacksonville, Fla. Filed May 1, 1901. Serial No. 58,362.

A device of the character specified, comprising two separate water-chambers, each having a valve water-inlet at its bottom and a valved air-vent at its top, an air-supply pipe connected with each of the chambers, a rotary valve carried by each of the said pipes and provided each with a crank-arm, a walking beam, a link carried by each of the ends of the walking-beam and connected to the said crank-arms, a rod connecting with each crank and with the air-vent valve, a shift-rod in each of the chambers, a water-holding cup carried by each of the shift-rods, a connection between each shift-rod and the cranks of the rotary valve, and valved discharge-pipes having their lower ends disposed adjacent to the lower ends of the said chamber.

695,771. AIR-BRAKE. Philip W. Vogt, St. Louis, Mo. Filed Dec. 30, 1901. Serial No. 87,677.

An air-brake, a suitable steam or air cylinder having central inlet and outlet openings; pistons mounted in said steam or air cylinder, one on each side of said openings; piston-rods extending from said pistons outwardly through the heads of said cylinder, and means of connecting said piston-rods to the brakes, said connections being crossed so that the brakes are tightened by admitting steam or air between the pistons, and loosened by exhausting steam or air from between the pistons.

695,948. AIR-VENT. Alfred Roesch, Bridgeport, Conn., assignor to the Davis & Roesch Temperature Controlling Company, a Corporation of New Jersey. Filed May 5, 1899. Serial No. 715,708.

An air-vent for heating systems, the combination with a tube constituting an air-discharge, of a valve for controlling said discharge, a rod carrying said valve, a thermostat supporting said rod and adapted to raise the rod or permit the rod to lower to correspondingly move the valve under variation in temperature, and a diaphragm adapted to raise and lower said rod independently of said thermostat under variations in pressures.

696.009. AIR CUSHIONS FOR VALVES. Joshua W. Cregar, Philadelphia, Pa. Filed Feb. 4, 1901. Serial No. 45,884.

A cushioned valve, a head and spout, a water chamber having a connection for the water-pipe, secured to the head, a valve-seat at the junction of the head and chamber, an air-tube extending through the head and chamber, a lever connected to the upper end of the air-tube, a valve on the air tube intermediate of its length to engage the valve-seat.

696,059. AIR-CONDUCTING PIPE. Francis Line, Cleveland, Ohio. Filed June 27, 1899. Serial No. 722,050.

As a new article of manufacture, a hot-air pipe formed of a series of plain asbestos tubes and corrugated asbestos filling the space between said tubes, whereby air-cells are formed in the pipe between the tubes, and a joint for connecting the tubes comprising two members each provided with an inner and outer vertical portion, connected by an inclined portion having a shoulder, and inner and outer oppositely-disposed recesses, the inner recess adapted to receive the ends of the tubes, and the outer recess adapted to receive the outer vertical portion of the opposite member of the joint.

696,277. AIR-CHAMBER FOR PUMPS. John E. Sponseller and George Fenno, Hoisington, Kan. Filed June 19, 1901. Serial No. 65,150.

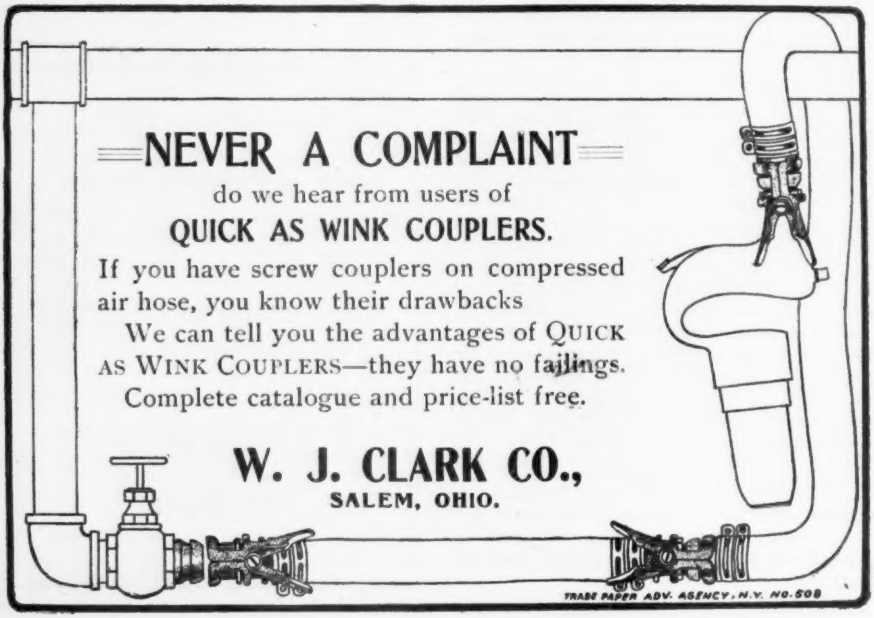
An apparatus, an air-chamber composed of the casing, the reducer threaded on the upper end of the casing and having its reduced portion provided with threads to receive the upper pump-pipe section and also to receive the upper end of the central pipe-section of the air-chamber, the central pipe-section threaded at its upper end in the upper reducer, provided near its lower end with openings for the passage of the water and air and having such lower end tapered externally, and the lower reducer threaded on the lower end of the casing and having its reduced portion provided with threads for the connection of the lower pump-pipe section and having said reduced portion formed interiorly at its inner end to provide a seat for the tapered outer side of the lower end of the central pipe-section.

696,305. PNEUMATIC-DESPATCH-TUBE SYSTEM. Thomas Bemis, Indianapolis, Ind. Filed Sept. 25, 1901. Serial No. 76,-453.

A pneumatic-despatch-tube system, a curved tubular section therefor, and a movable wall portion adapted to be moved in the direction of travel of a carrier passing around said curve.

696,387. PNEUMATIC MOTOR. John W. Birkenstock, New York, N. Y., assignor, by direct and mesne assignments to the Empire Pneumatic Tool Company, New York, N. Y. Filed May 7, 1901. Serial No. 59,141.

The combination of a casing provided with an enlargement at one end, a head at the other end of the same provided with channels for supplying compressed air, a head at the enlarged end of the casing, cylinders in said casing, and provided with inlet and outlet ports, pistons in said cylinders, a crank-shaft supported in the enlarged end of the casing, piston-rods connecting the pistons with the cranks of said crank-shaft, cams on said crank-shaft, slide-valves actuated by said cams and guided in the channeled head of the casing, said slide-valves being provided with ports communicating with the supply-channels for compressed air, and means for transmitting the rotary motion of the crank-shaft to the tool to be operated.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